Antarctic Marine Living Resources program

The U.S. Antarctic Marine Living Resources (AMLR) program: 1995–1996 field season activities

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The U.S. Antarctic Marine Living Resources (AMLR) program has developed and conducted a research plan tailored to the goals of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic Treaty System. The Convention manages antarctic fisheries to conserve targeted species, while also taking into account the impact fishing activities might have on other living organisms in the antarctic ecosystem. CCAMLR's unique management regime has come to be known as the "ecosystem approach." In keeping with CCAMLR's mandate, the impact of the krill (*Euphausia superba*) fishery upon dependent predators must be understood.

The AMLR program monitors finfish and krill fisheries, projects sustainable yields where possible, and formulates management advice and options. In addition, the program conducts field research with the long-term objective of describing the functional relationships between krill, their predators, and their environment. The field program is based on two working hypotheses:

- Krill predators respond to changes in the availability of their food.
- The distribution of krill is affected by both physical and biological aspects of their environment.

Similar to the past seven field seasons, the 1995–1996 field program included a 2-month research cruise near Elephant, Clarence, and King George Islands, which are among the South Shetland Islands at the tip of the Antarctic Peninsula (figure 1). The cruise was conducted aboard the

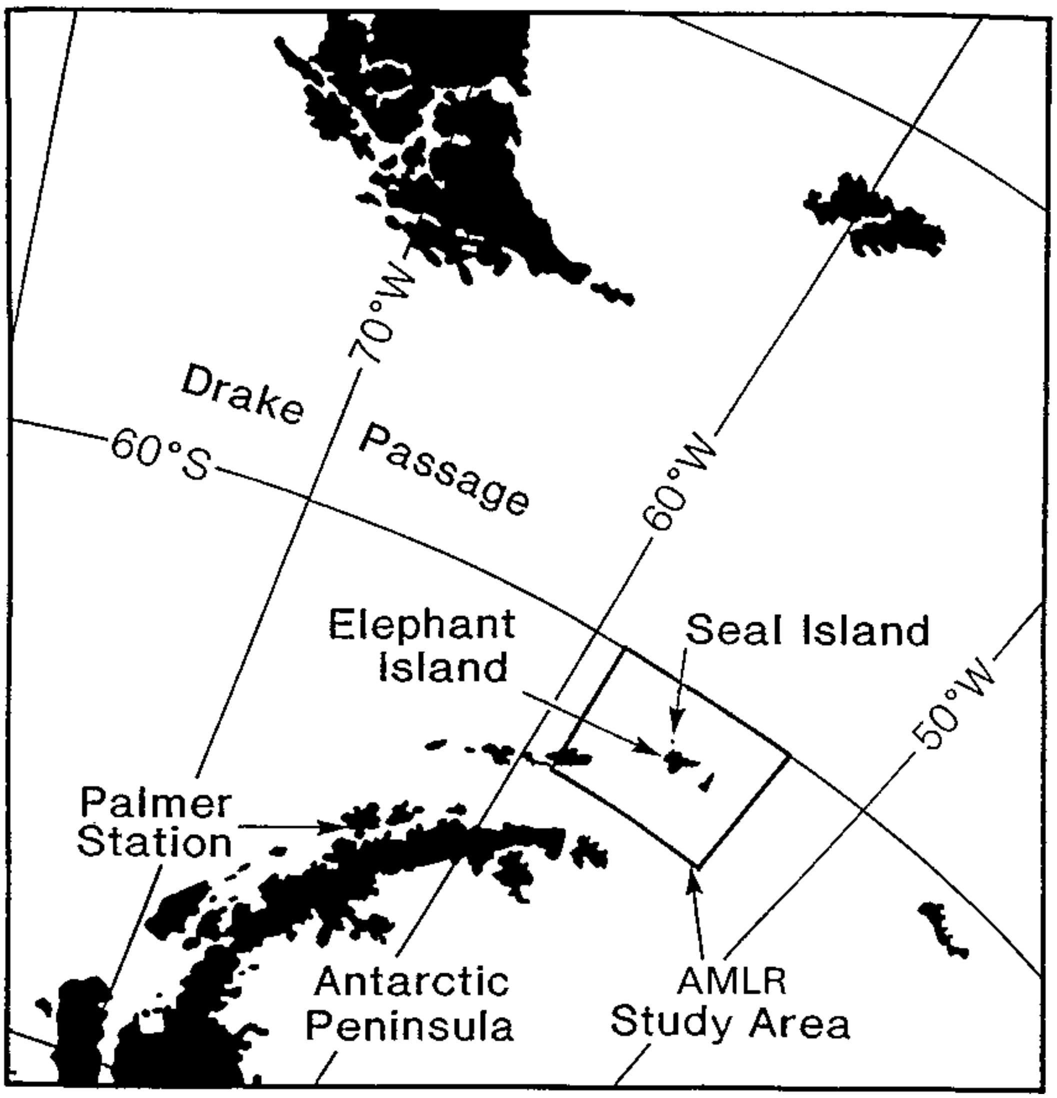

Figure 1. Locations of the U.S. AMLR field program: research cruise near Elephant, Clarence, and King George Islands (AMLR study area); and land-based studies at Seal Island and Palmer Station.

chartered research vessel (R/V) *Yuzhmorgeologiya*. Land-based studies were conducted at a seasonal field camp on Seal Island, off the northwest coast of Elephant Island, and at Palmer Station, a U.S. scientific station on Anvers Island farther south on the Peninsula (figure 1).

The specific objectives of the field season were the following:

- to map the physical structure of the upper 750 meters, including the thermohaline composition, oceanic fronts, water mass boundaries, surface currents, eddies, and turbulent mixing;
- to map the distribution of phytoplankton biomass and production;
- to map the distribution of zooplankton (krill and other species), including the horizontal and vertical variations in krill density and demographic characteristics;
- to conduct a census of antarctic fur seal pups at selected sites in the South Shetland Islands;
- to describe the abundance and growth rates of land-based krill predators (pinnipeds and seabirds) for part of the reproductive season on Seal Island; and
- to describe the reproductive success, feeding ecology, and growth rates of Adélie penguins (*Pygoscelis adeliae*) throughout the reproductive season at Palmer Station.

The R/V *Yuzhmorgeologiya* departed Punta Arenas, Chile, on 18 January 1996 to begin Leg I of the AMLR cruise; the leg was completed on 16 February. Following a mid-cruise port call, Leg II was conducted 19 February to 17 March. A large-area survey of 91 conductivity-temperature-depth (CTD)/rosette and net sampling stations, separated by acoustic transects, was completed once during each leg near Elephant, Clarence, and King George Islands (Survey A on Leg I, Stations A1–A91; Survey D on Leg II, Stations D1–D91; figure 2). Data for physical oceanography, primary productivity, and krill distribution and condition studies were collected during the large-area surveys. Operations at each station included the following:

- measurements of temperature, salinity, oxygen, light, transmissometer, and fluorescence profiles;
- collection of discrete water samples at standard depths for analysis of chlorophyll-*a* content, absorption spectra, particulate organic carbon and nitrogen concentrations, primary production, size fractionation, floristics, and inorganic nutrient content; and
- deployment of a 1.8-meter (6-foot) Isaacs-Kidd Midwater Trawl (IKMT) to obtain samples of zooplankton and nekton.

During Leg I, acoustic data and four IKMT samples were collected along two transects (Transects AB1 and AB2) when entering and leaving Admiralty Bay, King George Island, to

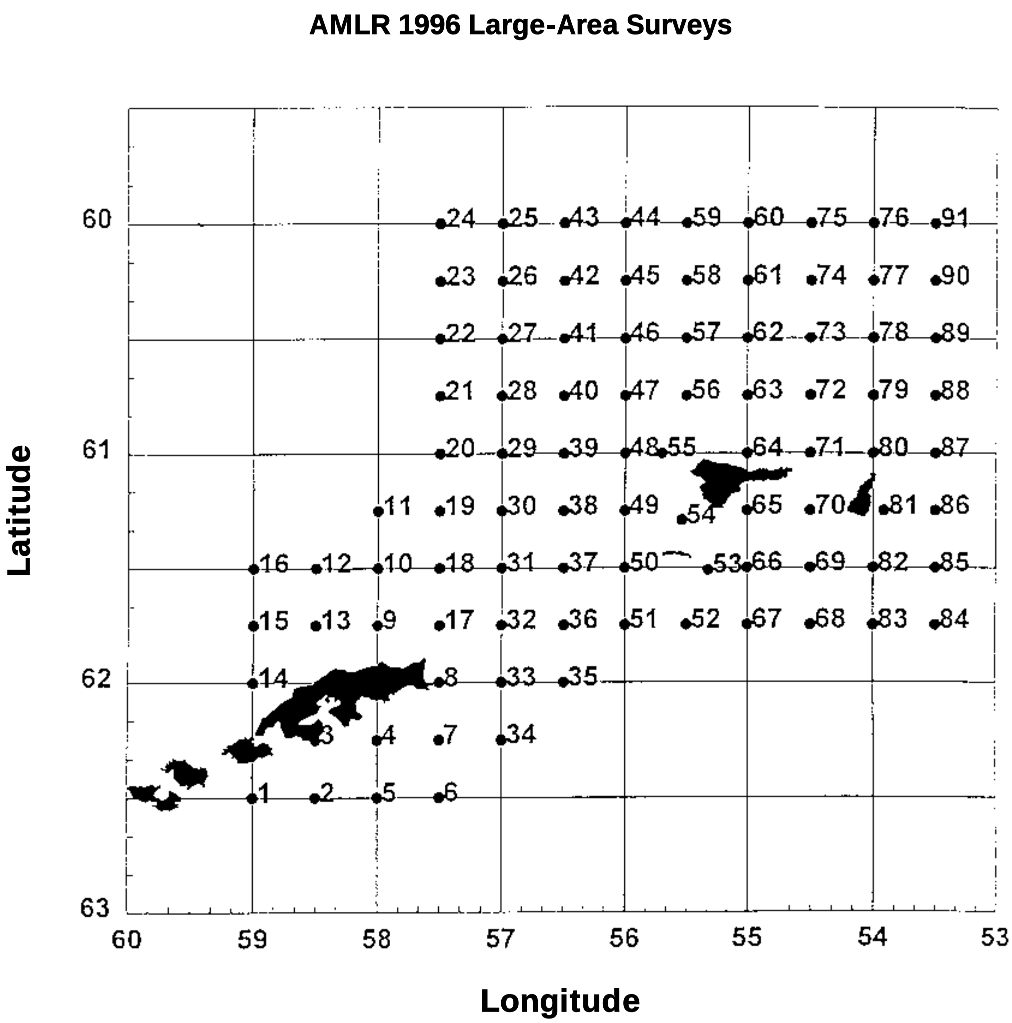

Figure 2. The large-area surveys for AMLR 1996 (Leg I: Survey A; Leg II: Survey D).

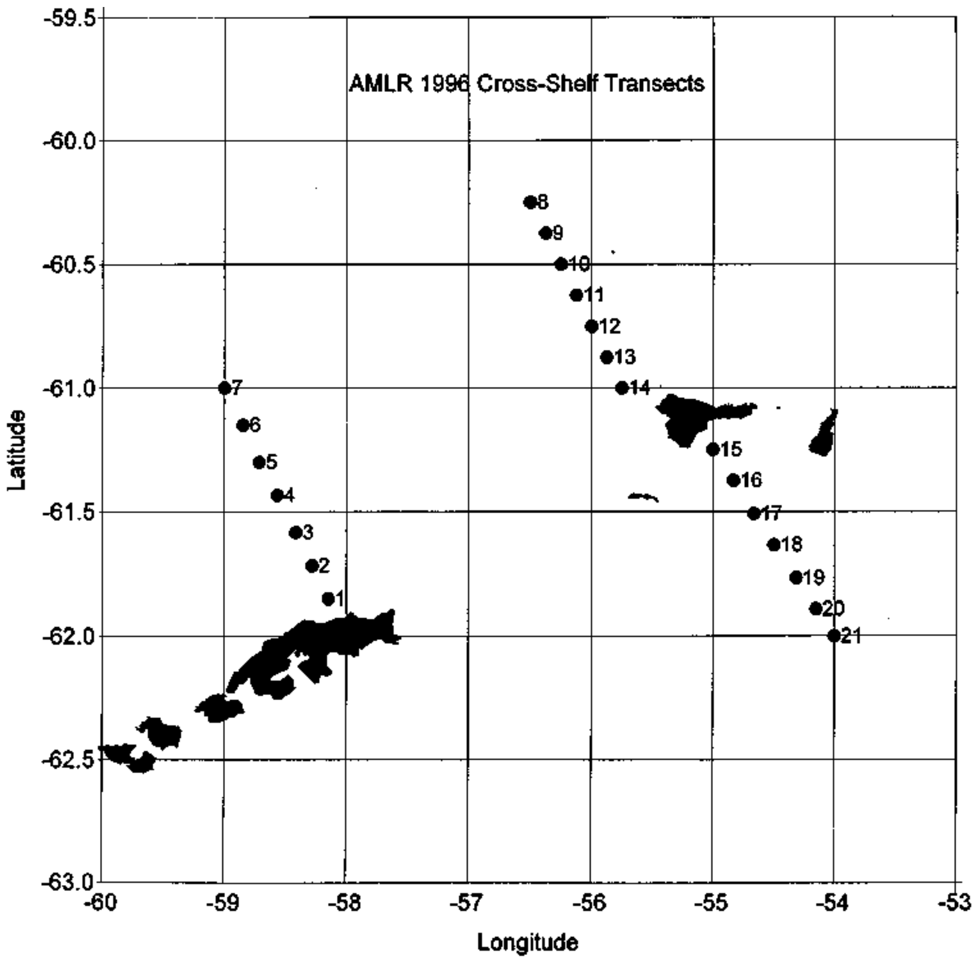

Figure 3. Three cross-shelf transects conducted during Leg II: north of King George Island (Stations X1–X7), north of Elephant Island (Stations X8–X14), and south of Elephant Island (Stations X15–X21).

describe krill abundance and distribution; these data complemented foraging studies on Adélie penguins in the area. An antarctic fur seal (*Arctocephalus gazella*) census was conducted throughout the South Shetland Islands during Leg I; fur seal pups were counted, newly established or previously unknown fur seal colonies were identified, and sightings of previously tagged fur seals were recorded. During Leg II, 21 CTD/rosette stations (Stations X1–X21) were completed along three cross-shelf transects to describe water mass structure: north of King George Island, north of Elephant Island, and south of Elephant Island (figure 3). Twenty-three directed net tows were also conducted in these areas using a Multiple Opening Closing Net Environmental Sampling System (MOCNESS) to correlate acoustic data with species and target sizes.

A field team occupied the camp on Seal Island from 21 January to 5 February 1996 and again 12–23 February 1996. The team conducted research on the abundance and growth of antarctic fur seals, chinstrap penguins (*Pygoscelis antarctica*), and macaroni penguins (*Eudyptes chrysolophus*) breeding on the island. Fieldwork at Palmer Station was initiated on 10 October 1995 and completed on 27 March 1996; studies on aspects of the ecology of Adélie penguins were conducted.

AMLR program: Distribution of volume backscattering strength near Elephant Island in the 1996 austral summer

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The primary objectives of the bioacoustic sampling program were to map the mesoscale (10s of kilometers) dispersion of krill (*Euphausia superba*) near Elephant Island, to estimate their biomass, and to determine their association with predator foraging patterns, water mass boundaries, spatial patterns of primary productivity, and bathymetry. Secondary objectives were to describe cross-sections of volume backscattering strength along transects through Admiralty Bay, across the shelf break to the north and south of the South Shetland Islands, and across the Antarctic Convergence in Drake's Passage. Directed net sampling was also conducted to verify classification of acoustic targets. *In situ* target strength (TS) measurements of individual zooplankton were made; these data will be used to develop or enhance TS models for various macrozooplankton and nekton.

Acoustic data were collected using a multifrequency echo sounder configured with downlooking 38, 120, and 200 kilohertz (kHz) transducers mounted in the hull of the ship. System calibrations were conducted before and after the surveys using standard sphere techniques while the ship was at anchor in Ezcurra Inlet, King George Island. For the purposes of generating distribution maps and biomass estimates, 120-kHz volume backscattering strength attributed to krill was integrated over depth from 10 meters (m) to 250 m and averaged over transect intervals of 185 m (18 pings assuming nominal vessel speed of 10 knots and 2-second ping interval).

Integrated volume backscattering strength per unit sea surface area was converted to estimates of krill biomass density by applying a factor equal to the quotient of the weight of an individual krill and its backscattering cross-sectional area, summed over the sampled length frequency distribution for each survey (Hewitt and Demer 1993). Total biomass was estimated by treating the mean biomass density on each transect as an independent estimate of the mean density over the survey area (Hewitt and Demer 1993). The entire survey area was treated as a single stratum.

Survey A (23 January to 4 February) and Survey D (24 February to 8 March) were conducted to map the mesoscale dispersion and estimate the biomass of krill in 15,000 square nautical miles near Elephant Island and the eastern end of King George Island. Each survey consisted of 12 north-south transects with 15-nautical-mile spacing between lines. Stations were 15 nautical miles apart and included a conductivity-temperature-depth cast and an Isaacs-Kidd Midwater Tow (IKMT) plankton tow.

During both surveys, areas of high krill density were mapped in wide bands along the north side of King George and Elephant Islands, where water depth was greater than 200 m (figure 1). The bands widened north of Elephant Island, where water flowing north from Bransfield Strait impinged on the general northeast flow along the north side of the South Shetland Islands. This distribution pattern is similar to that observed during previous surveys.

Krill biomass, estimated from the acoustic data for the area outlined in the box on figure 1, was the highest estimated since 1992 (table). High biomass estimates during Survey A represent large numbers of juvenile krill that were spawned in 1995; high biomass estimates during Survey D represent moderate numbers of sexually mature adults.

Acoustic data were collected along transects through Admiralty Bay during the approach (Transect AB1) and again during the departure (Transect AB2) from the anchorage at Ezcurra Inlet (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue). Four IKMT tows were conducted during the transects as well; two on the way in and two on the way out. The diets of chinstrap, Adélie, and gentoo penguins were sampled concurrently at colonies along the shores of Admiralty Bay by Nina Karnovski at the Copacabana field camp.

The acoustic and IKMT data indicate a layer of dense swarms existed between 50 and 150 m depth throughout the extent of the Admiralty Bay but not extending into Bransfield Strait (figure 2). Krill length-frequency distributions from the IKMT tows indicated that the krill in the area comprised two modal size groups centered around 26 and 48 millimeters (mm). These modes are similar to that observed last year in Admiralty Bay, except that the larger mode is about 5 mm longer. The krill length frequency distributions from penguin diet samples indicated no significant differences between penguin species and also that the penguins may have been feeding selectively on larger krill.

Krill aggregations encountered during Transect AB2 appear to be slightly higher in the water column than during Transect AB1, particularly during the latter portion of Transect AB2. This increase is likely due to the vertical movement of krill into shallower waters beginning at dusk. It has been suggested that krill reflect less sound during times of vertical migration when their body orientation with respect to the vertical is steeper. This explanation may be an alternative to the apparent decrease in krill between the two transects.

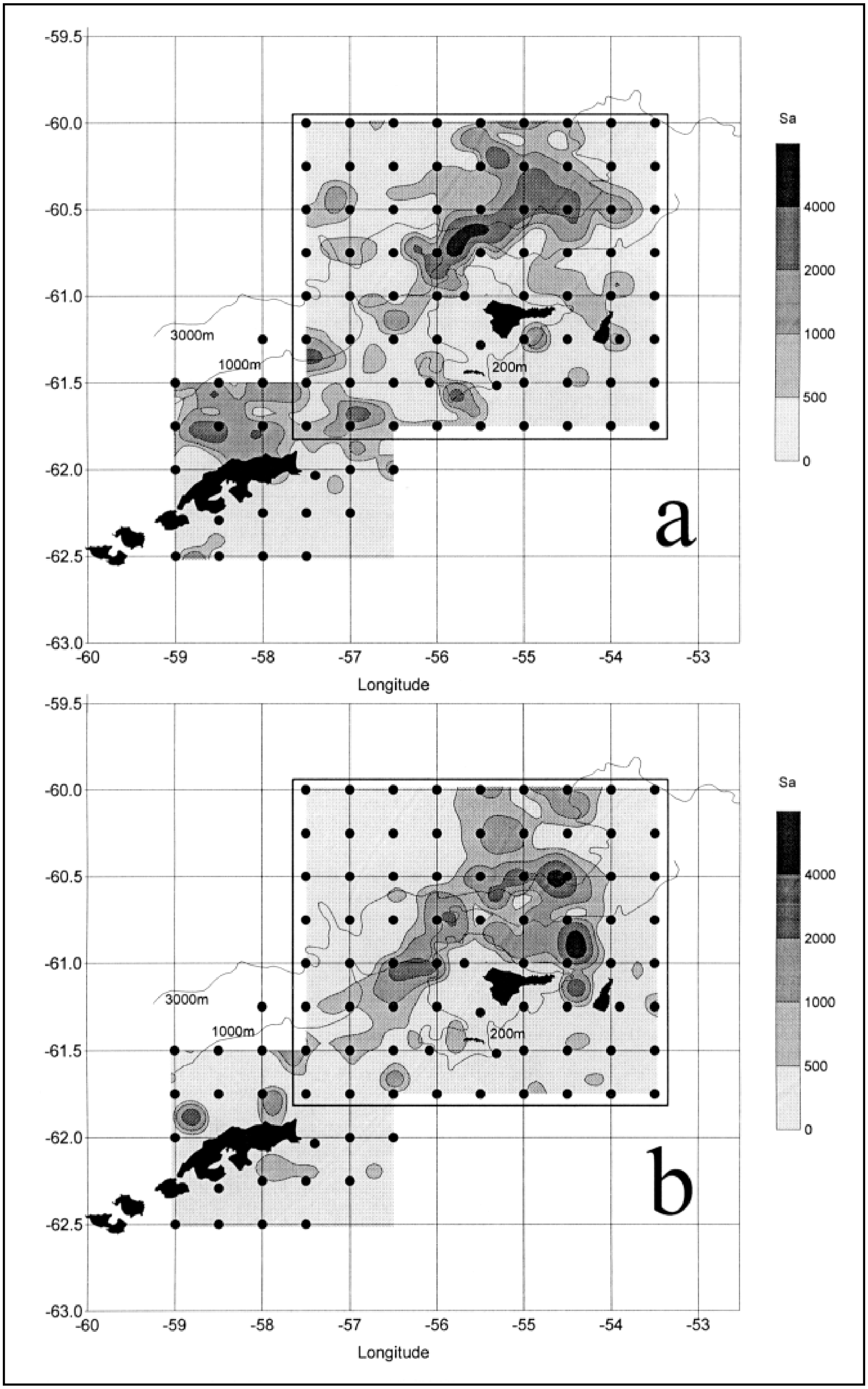

Figure 1. Distribution of volume backscattering strength during Survey A, 23 January to 4 February 1996 (*A*), and during Survey D, 24 February to 8 March (*B*). Mean krill biomass was estimated for area inside box.

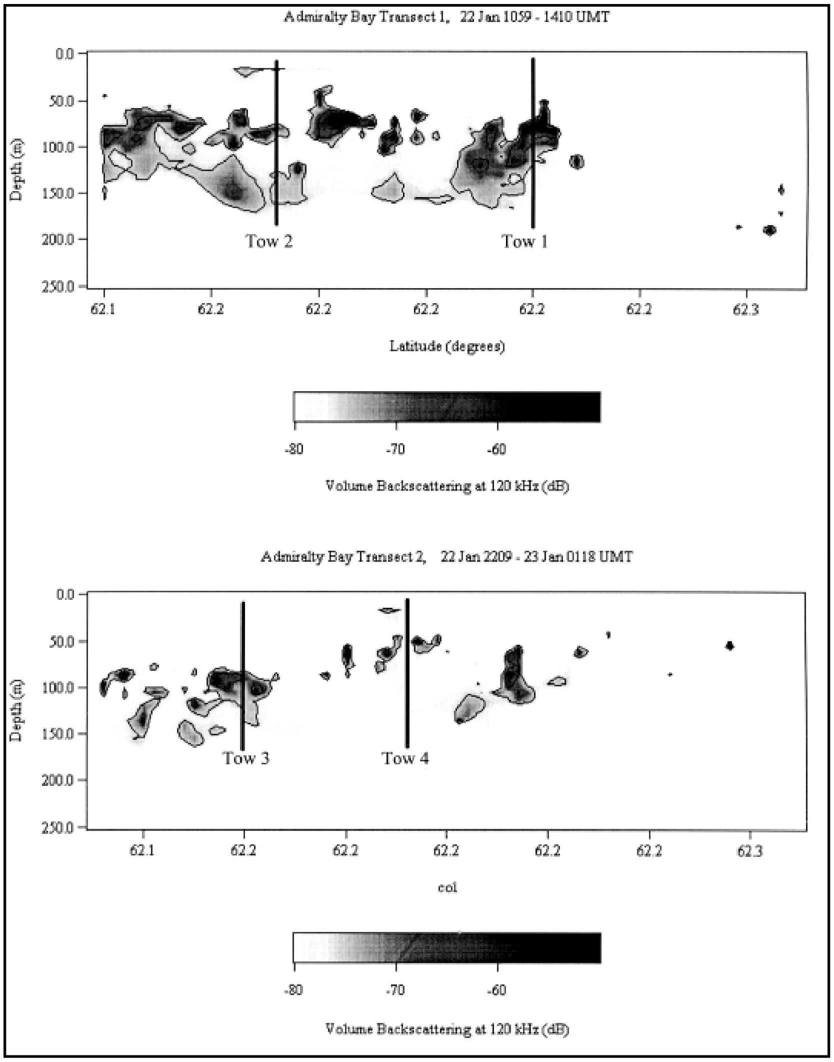

Figure 2. Vertical cross-sections of volume backscattering strength at 120 kHz on Admiralty Bay transects. Transect 1 was conducted from 1059 to 1410 universal mean time (UMT), 22 January, and Transect 2 was conducted from 2209 UMT 22 January to 0118 23 January.

Mean krill biomass density for surveys conducted during 1992 through 1996. Mean biomass is estimated for the area inside the box outlined on figure 1.

*** denotes previously reported biomass density values for 1993 that are suspicious because of problems with equipment performance and possible misinterpretation of backscatter from salps; these values are omitted here.*

Year and survey	Mean krill biomass density[a]	Coefficent of variation (%)
1992 Survey A (January)	61.20	16
1992 Survey D (February/March)	29.63	9
1993 Survey A (January)	**	**
1993 Survey E (February/March)	**	**
1994 Survey A (January)	9.63	11
1994 Survey D (February/March)	7.74	22
1995 Survey A (January)	28.78	12
1995 Survey D (February/March)	35.52	24
1996 Survey A (January)	76.26	11
1996 Survey D (February/March)	69.37	23

[a]In grams per square meter.

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AMLR program: Primary production and distribution of chlorophyll-*a* around Elephant Island, Antarctica, January to March 1996

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The area around Elephant Island, the study site of the U.S. Antarctic Marine Living Resources (AMLR) Program, is especially interesting because its physical, chemical, and biological characteristics have been reported to be extremely variable in regard to both spatial and temporal considerations (El-Sayed 1988, pp. 101–119; Helbling, Villafañe, and Holm-Hansen 1995; Silva et al. 1995; Villafañe, Helbling, and Holm-Hansen 1995). This region is also very productive in regard to the commercial harvesting of the antarctic krill, *Euphausia superba* Dana (Marr 1962), particularly over the continental shelf-slope north of Elephant Island (Macaulay, English, and Mathisen 1984). In this article, we report on the distribution of chlorophyll-*a* and primary production parameters in the AMLR study area during the austral summer of 1996.

The large-area survey grid, which consisted of 91 conductivity-temperature-depth (CTD)/rosette stations, was surveyed once during Leg I and once during Leg II. In addition, three cross-shelf transects were done, and extensive sampling was performed down to 2,000 meters (m) or to within 10 m of the bottom at shallower stations. More detailed information about the location of stations and transects is given in Martin, Hewitt, and Holt (*Antarctic Journal*, in this issue). Water samples were taken at 11 standard depths (5, 10, 15, 20, 30, 40, 50, 75, 100, 200, and 750 m or within 10 m of the bottom at shallow stations) from the 10-liter Niskin bottles mounted on the rosette. The following sensors were attached to the rosette to obtain continuous profile data of important variables in the upper water column:

- CTD sensors,
- a 25-centimeter pathlength transmissometer,
- a light sensor for photosynthetically available radiation (PAR, 400–700 nanometers), and
- a pulsed fluorometer.

Chlorophyll-*a* analyses were performed with samples taken from the upper 200 m depth following standard fluorometric techniques (Holm-Hansen et al. 1965) using a Turner Designs fluorometer. Samples of 100 milliliters were filtered through a GF/F Whatman glass fiber filter and the photosynthetic pigments extracted in absolute methanol; after at least 1 hour of extraction, chlorophyll-*a* concentrations were determined from the fluorescence of the extract (Holm-Hansen and Riemann 1978). The chlorophyll-*a* content of the nanoplankton fraction (cells <20 micrometers) was obtained in the same fashion, but the sample was first prefiltered through Nitex mesh with a pore size of 20 micrometers.

Samples for primary productivity measurements were taken at 5, 10, 15, 20, 30, 40, 50, and 75 m depth, placed in 50-milliliter polycarbonate tubes, and inoculated with 5 microcuries of sodium bicarbonate ($NaH^{14}CO_3$). The tubes were then placed in an incubator, which had neutral density screens to simulate the irradiance conditions existing at the depth from which the samples had been taken. The temperature of the samples in the incubator was maintained close to surface-water temperatures by pumping surface seawater through the incubator. After 6–8 hours of incubation under direct solar radiation, the samples were filtered (GF/F filter), exposed to hydrogen chloride (HCl) fumes, dried overnight, and the assimilated radiocarbon determined using standard liquid scintillation techniques. Incident solar radiation (PAR) was continuously recorded during both Legs using a 2-pi sensor mounted on the ship's superstructure.

The distributions of chlorophyll-*a* at 5 m depth during both Legs are shown in figure 1. A general increase of phytoplankton biomass from Leg I to Leg II occurred, and chlorophyll-*a* values were less than 2.5 milligrams per cubic meter (mg m^{-3}) throughout the study area during Leg I but reached values up to 5 mg m^{-3} to the east of King George during Leg II. In general, the lowest surface chlorophyll-*a* values were found in the northwest portion of the grid, whereas the highest chlorophyll-*a* values were found in Bransfield Strait waters and in the northeast portion of the sampling grid. The mean chlorophyll-*a* values at 5 m depth during Legs I and II were 0.85 and 1.5 mg m^{-3}, respectively. The proportion of nanoplanktonic cells was high during both Legs, in general accounting for more than 80 percent of the chlorophyll-*a*.

Figure 2 shows the depth distribution of chlorophyll-*a* along the three cross-shelf transects. In transect 1 (figure 2*A*), an area of relatively high chlorophyll-*a* values (more than 0.8 mg m^{-3}) was observed in the southern portion of the transect, and a deep chlorophyll-*a* maximum was evident at about 80 m depth. Transect 2 (figure 2*B*) had a more homogeneous distribution of chlorophyll-*a*, exhibiting low values (less than 0.8 mg m^{-3}) throughout almost the entire transect. The depth distribution of chlorophyll-*a* in transect 3 (figure 2*C*) was different from the other two, as it was characterized by high chlorophyll-*a* values in surface waters and diminishing concentrations with depth. The highest values observed (more than 2 mg m^{-3} from the surface to about 50 m depth) were found over the shelf drop-off.

The photosynthesis vs. irradiance (P vs. I) characteristics of phytoplankton in the AMLR sampling grid are shown in fig-

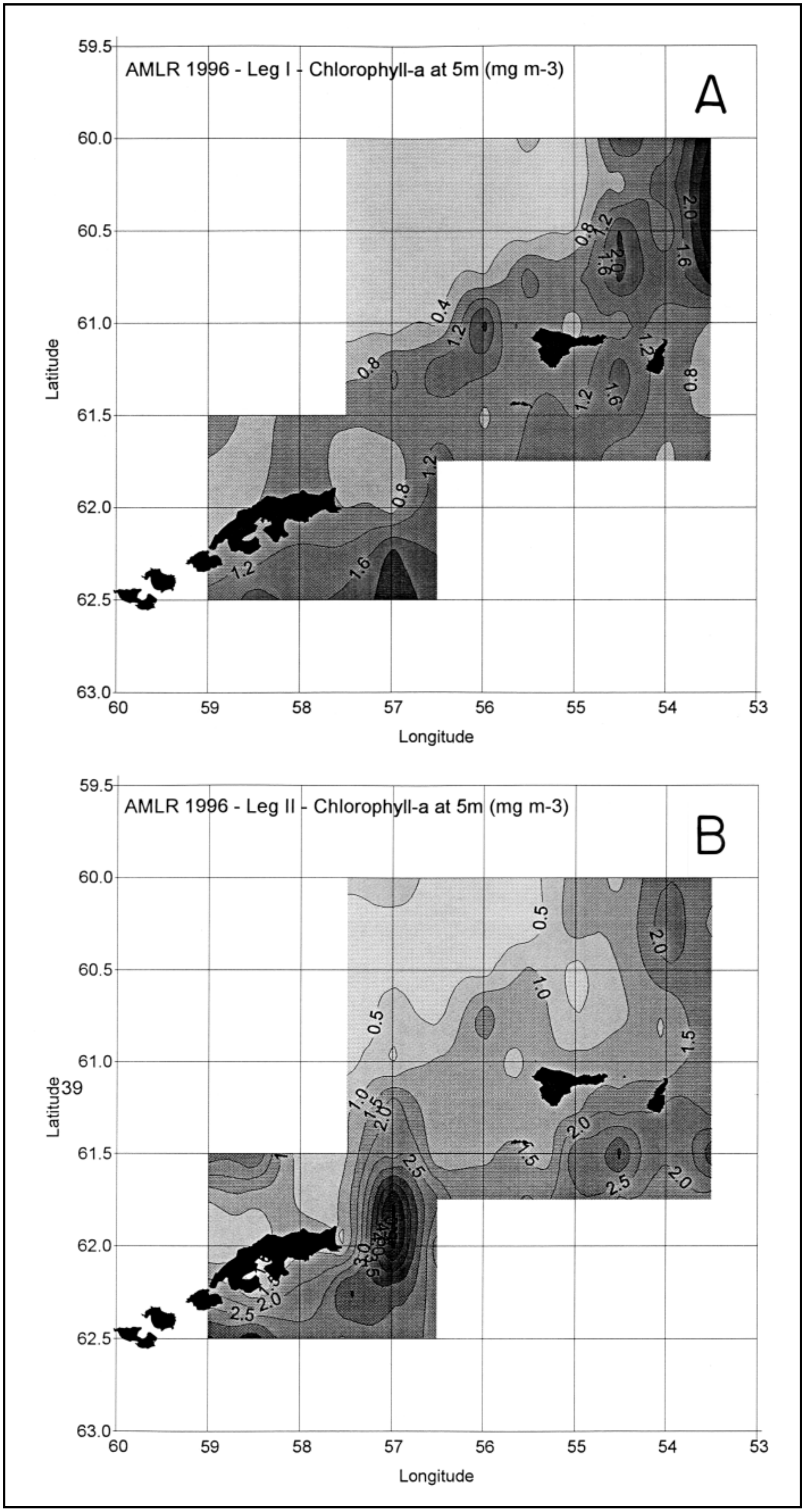

Figure 1. Chlorophyll-*a* concentrations (mg chlorophyll-*a* m^{-3}) at 5 m depth throughout the AMLR study area. *A*. Survey A (23 January to 4 February 1996). *B*. Survey D (24 February to 8 March 1996).

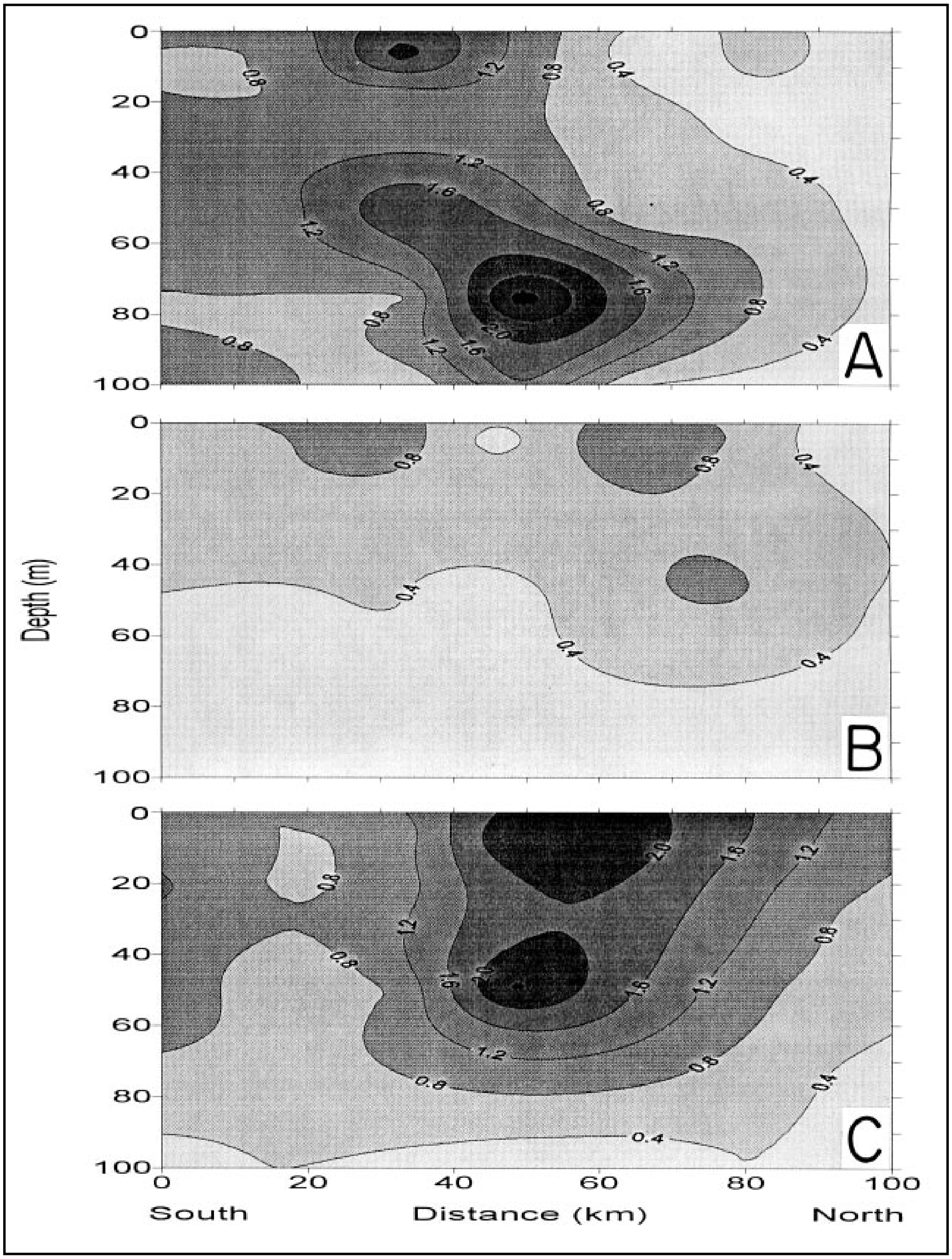

Figure 2. Distribution of chlorophyll-*a* in the upper 100 m of the water column along the cross-shelf transects. *A*. Transect 1. *B*. Transect 2. *C*. Transect 3. For location of transects, see Martin et al. (*Antarctic Journal,* in this issue). (km denotes kilometer.)

ure 3. The mean maximum values for assimilation numbers were slightly higher during Leg I than during Leg II (2.3 and 1.9 milligrams of carbon fixed per milligram chlorophyll-*a* per hour, respectively). The data in figure 3 illustrate that as irradiance increased, photosynthetic rates were somewhat inhibited. Because the samples were contained in polycarbonate tubes which absorb essentially all radiation below 360 nanometers, this inhibition could have been due to PAR, to ultraviolet radiation between 360 to 400 nanometers in wavelength, or to both. The values for mean daily PAR radiation during Legs I and II were 38 and 28 Einsteins per square meter per day, respectively.

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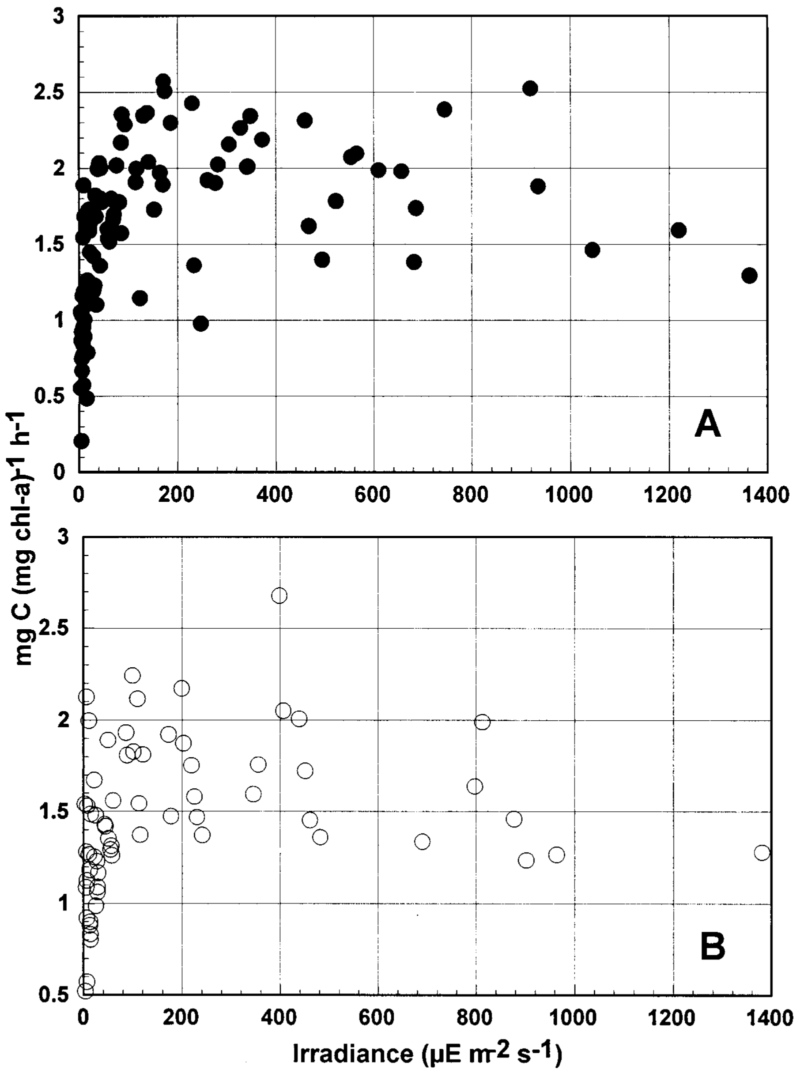

Figure 3. Photosynthetic characteristics (assimilation numbers) as a function of the mean irradiance during the incubation period for phytoplankton around Elephant Island. *A*. Data from Leg I. *B*. Data from Leg II. [mg C (mg chl-a)$^{-1}$ h^{-1} denotes milligrams of carbon per milligram of chlorophyll-*a* per hour. µE m^{-2} s^{-1} denotes microeinsteins per square meter per second.]

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AMLR program: Inorganic nutrient concentrations around Elephant Island, Antarctica, January to March 1996

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The main goals of the U.S. Antarctic Marine Living Resources Program (AMLR) include the study of the predator/prey interactions and the relationship between physical, chemical, and biological parameters in the marine ecosystem around Elephant Island, Antarctica. As a part of the phytoplankton component of this program, extensive nutrient sampling was carried out to relate chemical characteristics of water masses with phytoplankton distribution and concentration in the study area.

Although inorganic macronutrient concentrations are high (Le Jehan and Treguer 1985, pp. 22–29) and usually do not limit phytoplankton productivity in surface antarctic waters (Sakshaug and Holm-Hansen 1984, pp. 1–18), nutrient depletion has been documented in areas where large phytoplankton blooms occur, especially in coastal regions (Nelson and Smith 1986; Holm-Hansen et al. 1989; Holm-Hansen and Mitchell 1991). Previous studies in the area around Elephant Island have shown that nutrient concentrations are generally high (Silva et al. 1995a). During the AMLR 1995 field season, however, nitrate and phosphate concentrations decreased significantly in response to high concentrations of phytoplankton biomass, which at times exceeded 200 milligrams chlorophyll-*a* per square meter (Silva et al. 1995b; Villafañe et al. 1995).

The AMLR large-area survey grid, consisting of 91 conductivity-temperature-depth (CTD)/rosette stations, was occupied once during Leg I and once during Leg II. The cruise track and station positions for Legs I and II are given in Martin, Hewitt, and Holt (*Antarctic Journal*, in this issue). Samples for nutrient analysis were taken from the Niskin bottles attached to the CTD/rosette profiling unit. Water samples from 5 meters (m) depth were taken at all stations; additionally, samples were taken at 20, 50, and 100 m at the 24 stations where primary productivity measurements were made. The water samples (approximately 48 milliliters) were poured into 60-milliliter high-density polyethylene bottles that had been acid-cleaned. The bottles were immediately frozen and maintained at –20°C in an upright position until the time of analyses (1–2 months after collection), which were performed at the Universidad Católica de Valparaíso, Chile, using an autoanalyzer and standard analytical techniques (Atlas et al. 1971).

The distribution of silicic acid (figure 1) in near-surface waters during both Legs shows a pattern similar to the ones previously found by Silva et al. (1995a). The lowest concentrations (less than 40 micromolar) were in Drake Passage waters; higher concentrations (more than 70 micromolar) occurred toward the southeast (water type V; *see* Amos, Wickham, and Rowe, *Antarctic Journal*, in this issue) and south (Bransfield Strait waters) of the sampling grid. This gradient in silicic acid concentrations was present during both Legs and was most pronounced in the zone of the continental shelf-break and the continental slope to the north of Elephant Island.

Phosphate concentrations at 5 m depth (figure 2) were generally high during both Legs, with values generally ranging from 1.6 to 2.0 micromolar. The lowest phosphate concentrations found during Leg I (less than 1.7 micromolar; figure 2*A*) were in a large area to the north of Elephant Island. During Leg II (figure 2*B*), phosphate concentrations were generally higher in this area to the north of Elephant Island, but relatively low concentrations (less than 1.6 micromolar) were found to the south of Elephant Island and to the east of King George Island. These areas of low phosphate concentrations in Leg II coincided with the areas of greatest phytoplankton biomass (*see* Villafañe et al., *Antarctic Journal*, in this issue).

The distribution patterns of nitrate concentrations at 5 m depth during both Legs (figure 3) were similar to those of phosphate concentrations, including the relative changes from Leg I to Leg II. Nitrate concentrations during both Legs ranged from about 22 to 29 micromolar, with the lowest values during Leg I (21 micromolar; figure 3*A*) existing to the north of Elephant Island, and during Leg II (22 micromolar; figure 3*B*) to the east of King George.

The variations in inorganic nutrient concentrations shown above reflect different chemical characteristics of the water masses found in the AMLR study area (Silva et al. 1995a) as well as temporal changes related to the assimilation of these nutrients by phytoplankton. The relatively low phosphate and nitrate concentrations during our study period apparently are due to phytoplankton nutrient uptake because high phytoplankton concentrations were observed in these areas (Villafañe et al., *Antarctic Journal*, in this issue). Similar changes in nutrient concentrations from Leg I to Leg II were observed in the AMLR study area by Silva et al. (1995b), although in that study the minimal phosphate and nitrate concentrations were much lower (less than 1 micromolar phosphate and less than 19 micromolar nitrate). This greater depletion of nutrients during 1995 as compared to values in 1996 is correlated with higher chlorophyll-*a* concentrations in 1995 (approximately 8 milligrams per cubic meter) as compared to the highest chlorophyll-*a* concentrations of approximately 5 milligrams per cubic meter in 1996.

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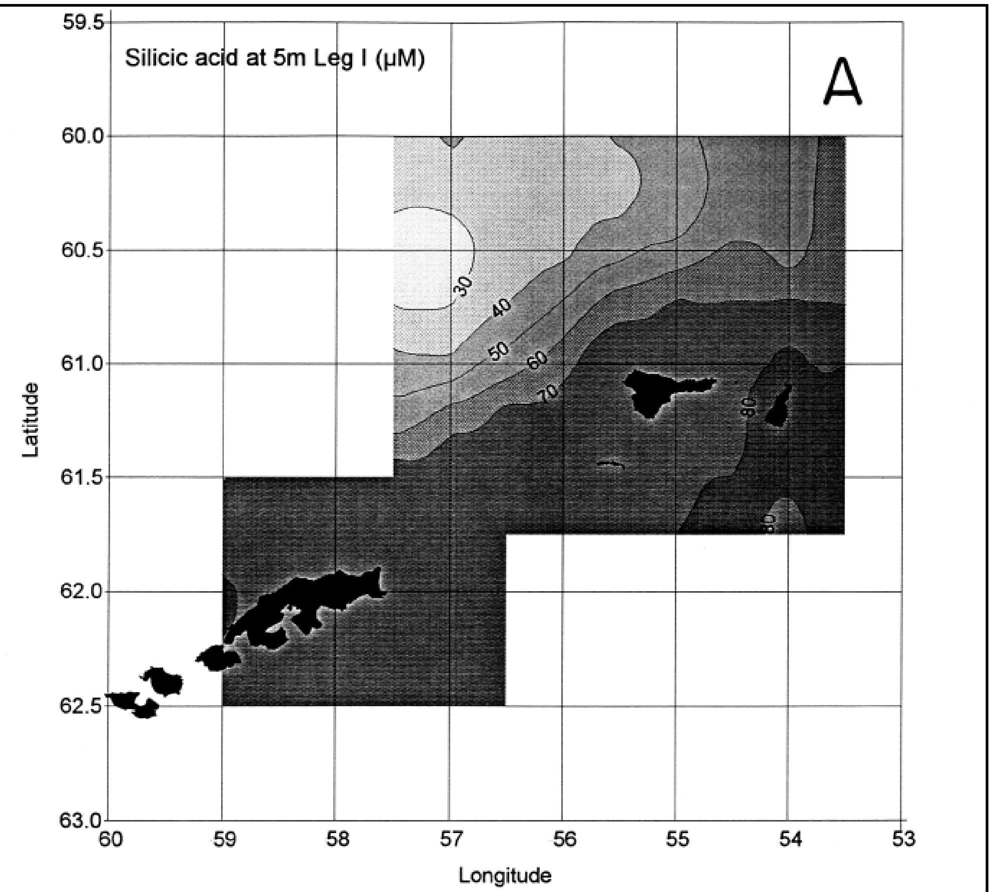
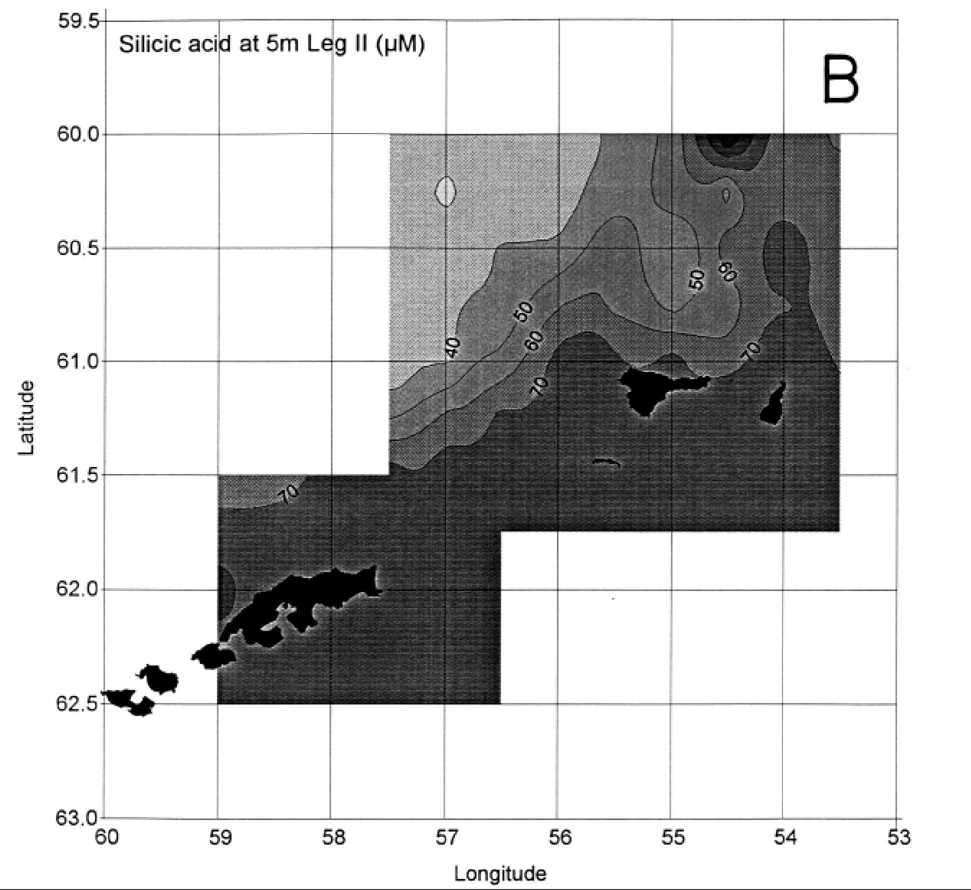
Figure 1. Silicic acid concentrations (micromolar) at 5 m depth in waters around Elephant Island. *A*. Data from Survey A, Leg I (23 January to 4 February 1996). *B*. Data from Survey D, Leg II (24 February to 8 March 1996).





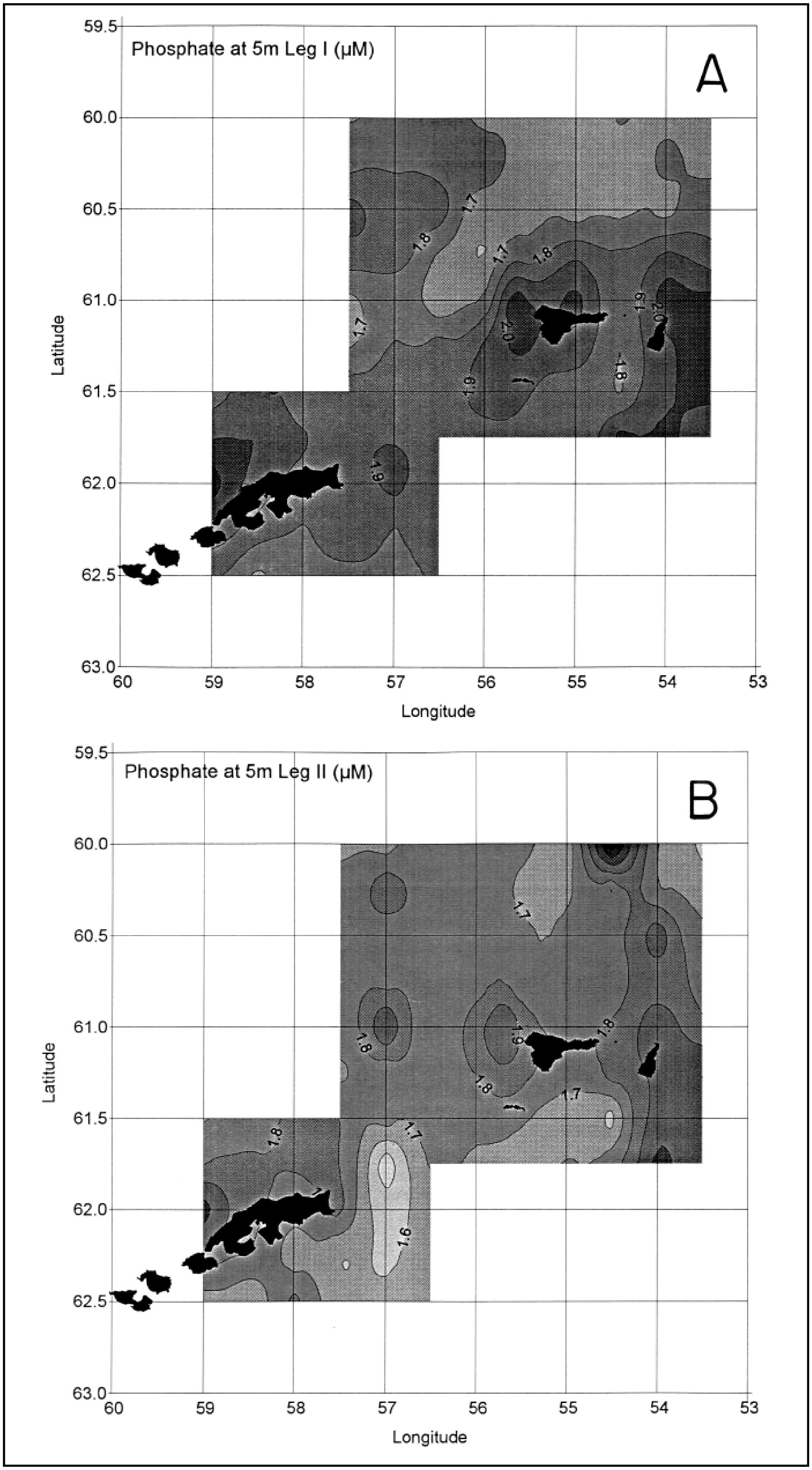


Figure 2. Phosphate concentrations (micromolar) at 5 m depth in waters around Elephant Island. *A*. Data from Survey A, Leg I (23 January to 4 February 1996). *B*. Data from Survey D, Leg II (24 February to 8 March 1996).

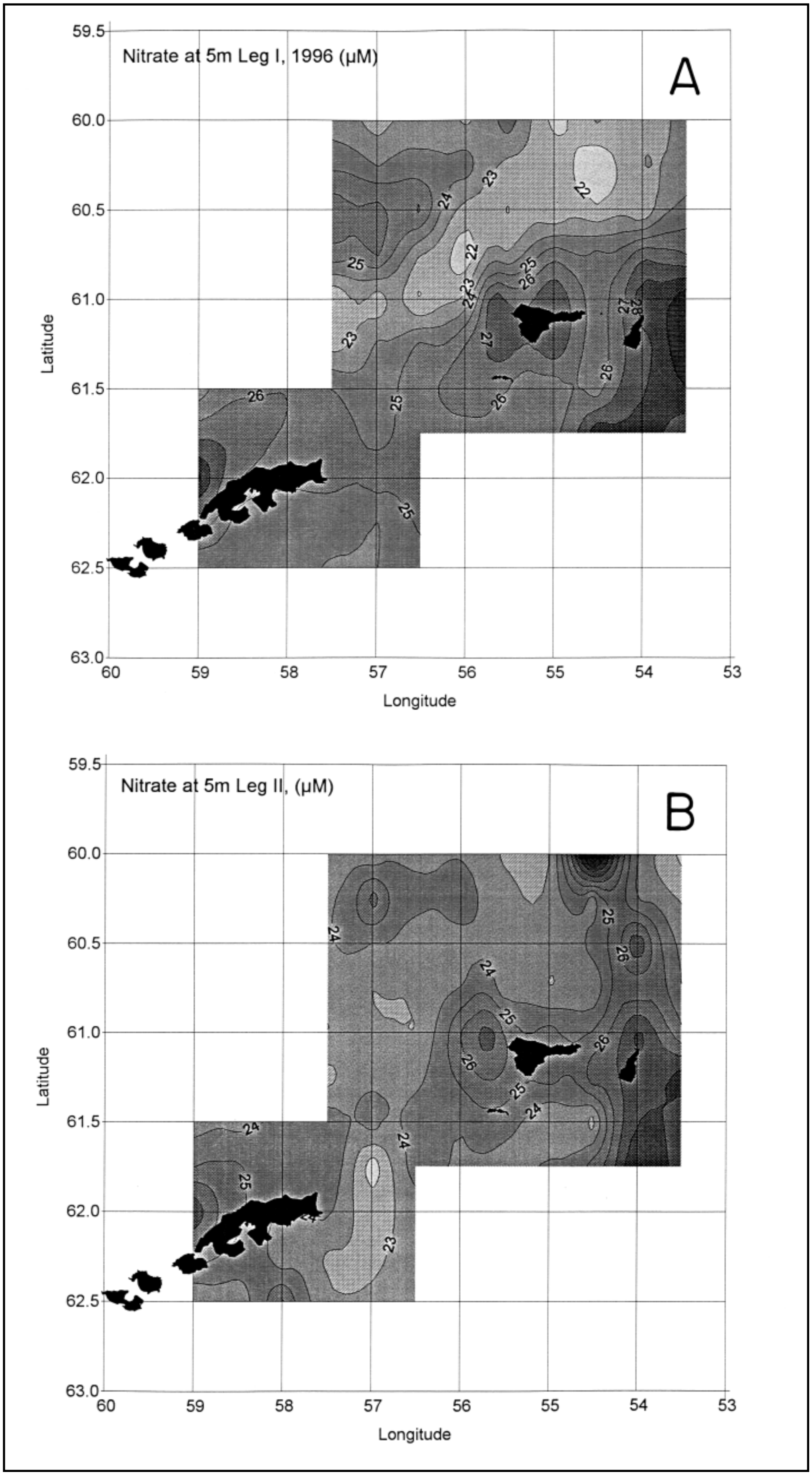


Figure 3. Nitrate concentrations (micromolar) at 5 m depth in waters around Elephant Island. *A*. Data from Survey A, Leg I (23 January to 4 February 1996). *B*. Data from Survey D, Leg II (24 February to 8 March 1996).

Grateful acknowledgment is extended to the officers and crew of the R/V *Yuzhmorgeologiya* for their excellent support during all field operations. We also thank M. Hernando for his help onboard ship, the Physical Oceanography group for kindly providing their CTD data, and A. Varas and N. Cáceres for their help in nutrient analysis. Shipboard personnel during Legs I and II included E.W. Helbling, V.E. Villafañe, and T.C. Calvete.

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AMLR program: Krill demography in the Elephant Island area, January to March 1996

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The objective of this work was to provide information on the demographic structure of antarctic krill stocks (*Euphausia superba*) in the Antarctic Marine Living Resources (AMLR) study area. Demographic information for krill includes length, sex, reproductive condition, and maturity stage composition. The length information is important to the AMLR acoustics program to estimate krill biomass. Information on length, maturity stage composition, and reproductive condition is essential to assess between-year differences in krill spawning success and recruitment (i.e., the supply of juveniles spawned the previous summer). The size of this supply has relevance to the availability of krill to their predators.

Krill were obtained from a 1.8-meter (6-foot) Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505-micrometer mesh plankton net. Flow volumes were measured using a calibrated General Oceanics flow meter mounted on the frame in front of the net mouth opening. Samples were collected at the 91 large-area survey stations during each cruise leg (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue). All tows were fished obliquely from a depth of 170 meters (m) or about 10 m above bottom in shallower waters. Tow depths were derived from a real-time depth recorder mounted on the trawl bridle and monitored in the acoustics lab. Tow speeds were about 2 knots. Samples were processed onboard using fresh or freshly frozen specimens. All krill were analyzed from samples containing fewer than 150 individuals. For larger samples, 100–200 individuals were measured, sexed, and staged. Measurements were made of total length [in millimeters (mm)]; stages were based on the classification scheme of Makarov and Denys (1981). Density estimates are expressed as numbers per square meter sea surface area. Data are presented for the large-area surveys and for the more restricted "Elephant Island Area" (a box around Elephant Island) to allow comparison with previous AMLR cruises (figure 1).

Krill were present at all but three stations during Survey A (23 January to 4 February), yielding an estimated total of 46,831 individuals. Relatively high krill densities occurred in waters over and adjacent to the northern and southeastern shelves of King George and Elephant Islands (figure 1). The relatively high mean abundance of 18.9 per square meter (m^{-2}) (±70.3) was mostly due to three large catches (233.4 to 579.6

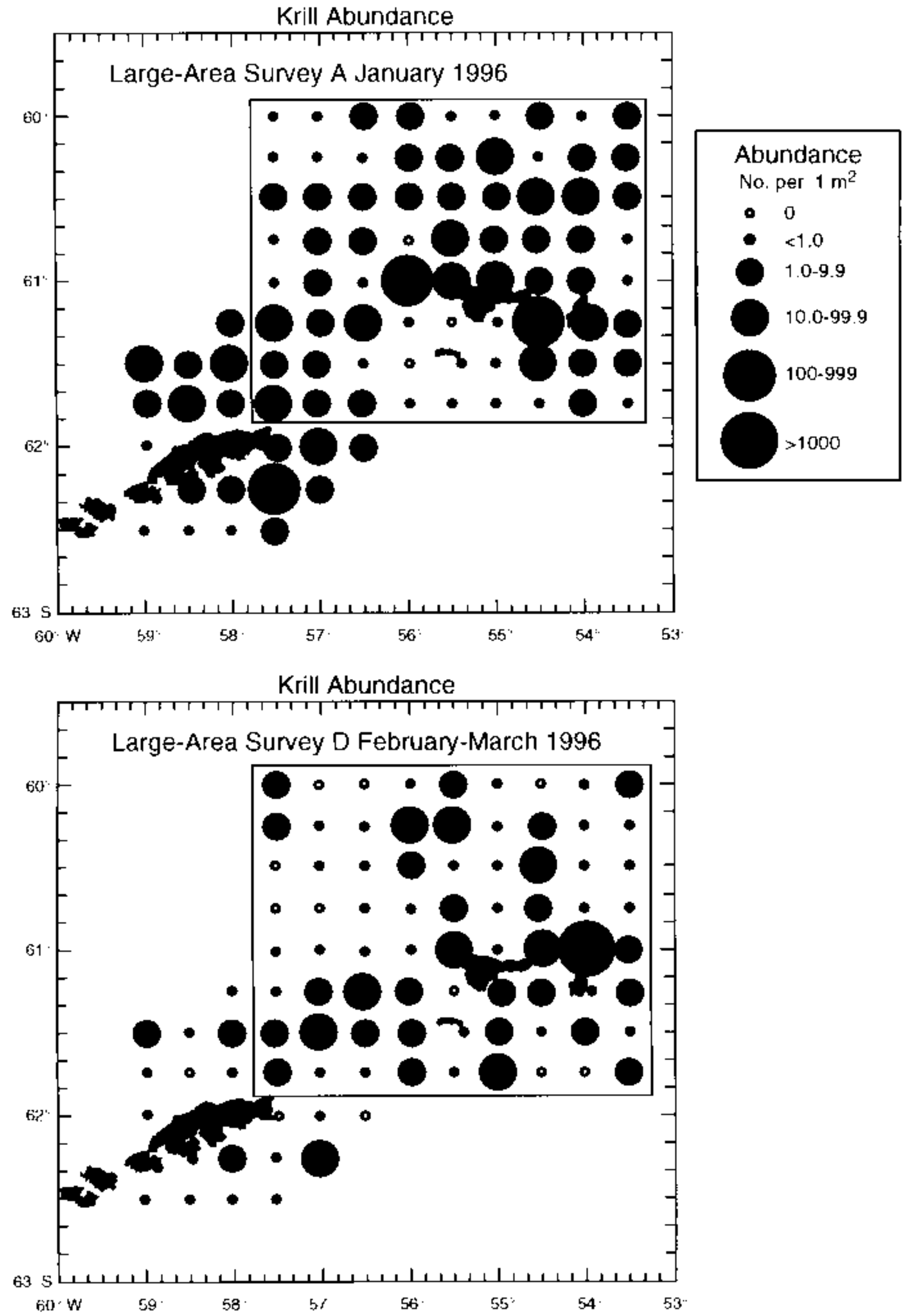

Figure 1. Krill abundance in IKMT tows collected during the large-area survey on Leg I (Survey A, January 1996) and during the large-area survey on Leg II (Survey D, February and March 1996). The outlined stations are included in the "Elephant Island area" used for between-year comparisons.

m^{-2}); the median abundance was 2.0 m^{-2}. The overall length frequency distribution was bimodal (figure 2) and numerically dominated (71.3 percent) by small krill 22 to 33 mm long; large krill of 44- to 53-mm lengths constituted the second mode (18.6 percent). The small length mode was due to large numbers of juveniles (63.2 percent) and immature males (2a stage; table) and represents a relatively abundant 1-year-old age class (i.e., the 1994–1995 year class). The large-size mode included primarily mature stages older than 4 years of age. Cluster analysis indicated that the small krill were broadly distributed across the southern portion of the survey area whereas large mature forms were primarily within the Drake Passage. Relatively small proportions of intermediate sized krill (34 to 43 mm, 7.5 percent) result from poor recruitment of the 1992–1993 and 1993–1994 year classes. Almost all of the mature females were in advanced stages: 24.6 percent had developing gonads (3c stage); 7.4 percent were gravid (3d); and 66.0 percent were spent (3e). The common occurrence of spent forms that still had numerous eggs remaining in the ovaries suggests that a substantial proportion of the females were undergoing batch spawning during the survey period.

Approximately 33,795 krill were collected at 79 Survey D stations (24 February to 8 March). The larger samples generally occurred in the area extending from northeast of King George Island to south and east of Elephant Island. The largest catch, estimated to be 26,650 krill (1,255.5 m^{-2}), was at Station D80 northeast of Clarence Island (figure 1). This sample represented 79 percent of the krill collected during Survey D. The extremely large krill catch overwhelms those from other survey stations and is generally omitted here to describe conditions characteristic of the broader survey area. For example, the mean krill abundance for all Survey D stations was 16.9 m^{-2} (±130.7), whereas that after excluding Station D80 was 3.1 m^{-2} (±7.0). The median abundance estimates with and without D80 were similar, 0.6 and 0.5 m^{-2}, respectively, reflecting relatively low abundance of krill across the survey area during this time.

The overall krill length-frequency distribution from the survey area (excluding D80) was again bimodal, and most of the krill were within 25- to 33-mm and 45- to 53-mm length categories (figure 2). In contrast to Survey A, large mature forms numerically dominated (71 percent), whereas juveniles and young immature males smaller than 34 mm constituted only 23 percent of the total (table). The distribution of these smaller krill was limited to a few stations adjacent to and south of Elephant Island. As during Survey A, most of the mature females were in advanced maturity stages: 57.6 percent were gravid (3d) and 22.1 percent spent (3e).

Mean and median krill abundance values in the Elephant Island area during Survey A were the highest recorded in the past 5 years (table). This high abundance was primarily due to

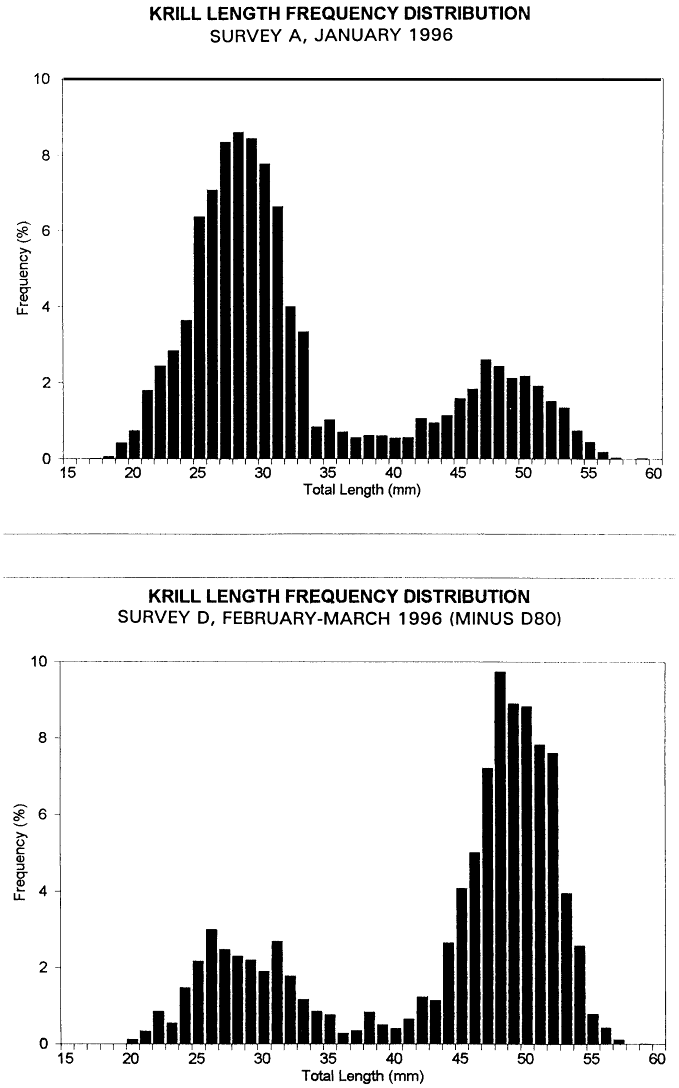

Figure 2. Overall length frequency distribution of krill collected during the large-area survey on Leg I (Survey A, January 1996) and during the large-area survey on Leg II (Survey D, February and March 1996).

large proportions of 1-year-old krill (juveniles and stage 2a males). The substantial decrease in Survey D krill abundance estimates relative to January values was also observed in February and March 1994 and 1995 and most likely represents seasonal migration out of the area. Decreased proportions of juveniles in February and March compared to January sampling periods have been observed each year and probably result from different distribution and seasonal migration patterns of the various maturity stages (Siegel 1988, pp. 219–230).

Most of the female krill were in advanced maturity stages during the 1995 and 1996 surveys (table), but smaller proportions of spent females and low numbers of krill larvae collected in February and March 1996 compared to 1995 (Loeb and Outram, *Antarctic Journal*, in this issue) suggest a later peak spawning period in 1996. The early spawning seasons of 1994–1995 and 1995–1996 differ substantially from the previous 3 years when most females were in early stages of gonadal development during the period from January to March.

The krill recruitment index (R1) based on the relative proportion of total krill constituted by the 1-year-old age group during Survey A was 0.622. This value was one of the highest recorded over the past 18 years and indicates strong recruitment of the 1994–1995 year class. Strong recruitment results from good spawning success and survival of early stages spawned the previous year. These two conditions were associated with large proportions of advanced female maturity stages during the period from January to March 1995 (table) and extensive sea-ice conditions in the Antarctic Peninsula region during winter 1995. These results support the hypothesized relations between krill recruitment success, krill spawning seasonality, and winter sea-ice conditions presented in Siegel and Loeb (1995). In accordance with the apparent relationship between early spawning and good recruitment, strong year class success may result from the relatively large proportions of advanced female stages during 1996.

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Abundance and maturity stage composition of krill collected in the Elephant Island area during 1996 compared to 1992–1995

NOTE: February and March 1996 values do not include data from station D80. Advanced female maturity stages are proportions of mature females that are 3c–3e in January and 3d–3e in February and March.

	January					February and March				
	1996	1995	1994	1993	1992	1996	1995	1994	1993	1992
Number of tows	**72**	**71**	**63**	**70**	**63**	**71**	**71**	**70**	**67**	**67**
Abundance:	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}	No. m^{-2}
Mean	13.6	1.6	5.5	5.8	3.5	3.6	0.9	2.3	6.8	6.0
Standard deviation	42.1	3.5	14.9	11.6	11.7	7.6	2.1	8.5	17.8	12.0
Median	1.9	0.6	0.5	1.7	0.9	0.7	0.2	0.06	0.6	1.1
Composition:	%	%	%	%	%	%	%	%	%	%
Juveniles	55.0	4.6	4.0	7.2	37.1	20.8	1.1	3.7	3.5	33.6
Immature stages	18.3	4.0	18.8	30.7	19.1	9.9	2.5	6.2	51.4	27.1
Mature stages	26.7	91.4	77.2	62.2	43.9	69.3	96.4	90.1	45.1	39.2
Females:										
F2	1.1	0.1	2.3	7.8	0.8	0.6	0.3	0.7	21.8	0.8
F3a	0.0	0.2	18.0	11.7	0.6	0.0	0.0	3.5	12.4	10.3
F3b	0.2	1.2	19.3	14.3	12.3	0.0	0.0	7.8	6.2	10.2
F3c	1.9	15.3	20.1	5.1	9.2	5.0	2.0	4.3	3.7	4.3
F3d	0.7	17.7	2.3	1.2	0.4	10.9	21.8	4.6	1.1	1.2
F3e	11.6	3.7	0.0	0.0	0.0	4.9	20.4	0.9	1.2	<0.01
Advanced Stages	(98.3)	(96.3)	(37.5)	(19.5)	(42.7)	(76.0)	(95.5)	(26.1)	(9.3)	(4.6)
Males:										
M2a	14.6	0.9	0.3	6.8	8.7	6.5	0.7	0.2	6.9	4.3
M2b	2.1	1.5	9.4	11.9	7.3	1.2	0.4	1.2	19.1	19.8
M2c	0.5	1.5	6.8	4.2	2.3	1.6	1.1	4.2	3.6	2.2
M3a	1.4	4.4	4.3	3.7	2.8	5.3	4.4	24.1	2.1	2.5
M3b	10.9	48.9	13.2	26.2	18.7	43.2	47.8	44.7	18.4	10.7
Number measured	4,296	2,294	2,078	4,283	2,472	2,984	1,271	1,155	3,669	3,646

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AMLR program: Salps and other macrozooplankton sampled, January to March 1996

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Salps (*Salpa thompsoni*) and other macrozooplankton taxa are important components of the antarctic pelagic ecosystem and food web. Salps are of particular interest because during the spring and summer months of some years, they may undergo explosive population growth and numerically dominate the zooplankton in the upper water column. During those times, salps may be a major competitor of krill for phytoplankton food resources (Siegel and Loeb 1995).

Macrozooplankton were collected along with krill using a 1.8-meter (6-foot) Isaacs-Kidd Midwater Trawl (IKMT). Sampling specifics are presented in Loeb and Siegel (*Antarctic Journal*, in this issue). All samples were analyzed onboard using fresh material. All salps were removed from the samples. For entire samples of fewer than 100 individuals, the two forms (aggregate/sexual and solitary/asexual) were enumerated, and internal body length (Foxton 1966) was measured to the nearest millimeter (mm). Representative subsamples of 50–150 individuals were analyzed for larger catches. After salps, krill, and adult fish were removed, the remaining zooplankton samples were analyzed. All larger organisms (e.g., amphipods, other euphausiids) were sorted, identified to the lowest taxon possible, and enumerated. The smaller constituents (e.g., copepods, euphausiid larvae) in representative aliquots were then enumerated using dissecting microscopes. Abundance estimates are expressed as numbers per 1,000 cubic meters (m^3) of water filtered. Data are presented for the entire large-area survey during each leg of the cruise.

Seventy taxonomic categories were identified in Survey A samples (23 January to 4 February). Copepods were present in all 91 samples and constituted the most frequent and abundant category (794.4 per 1,000 m^3; table). Larval stages of the euphausiid *Thysanoessa macrura* were second in abundance (308.5 per 1,000 m^3) and occurred in 90 percent of the samples. Among the larger zooplankton constituents, *T. macrura* postlarvae were most frequent (99 percent of tows) and ranked fourth in abundance. Postlarval *T. macrura* were most abundant in Bransfield Strait and waters adjacent to King George and Elephant Islands, whereas the larvae were most abundant in the Drake Passage (figure 1). These distributions are almost diametrical, as indicated by a significant negative correlation (Spearman's R = –0.40, $p<<0.001$) between the larval and postlarval abundance values at each station. Salps occurred in 65 percent of the samples and were the sixth most abundant taxon (20.4 per 1,000 m^3). They were most frequent and abundant in the Drake Passage (figure 2). Lengths ranged from 4 to 135 mm; the majority (74 percent) were 22 to

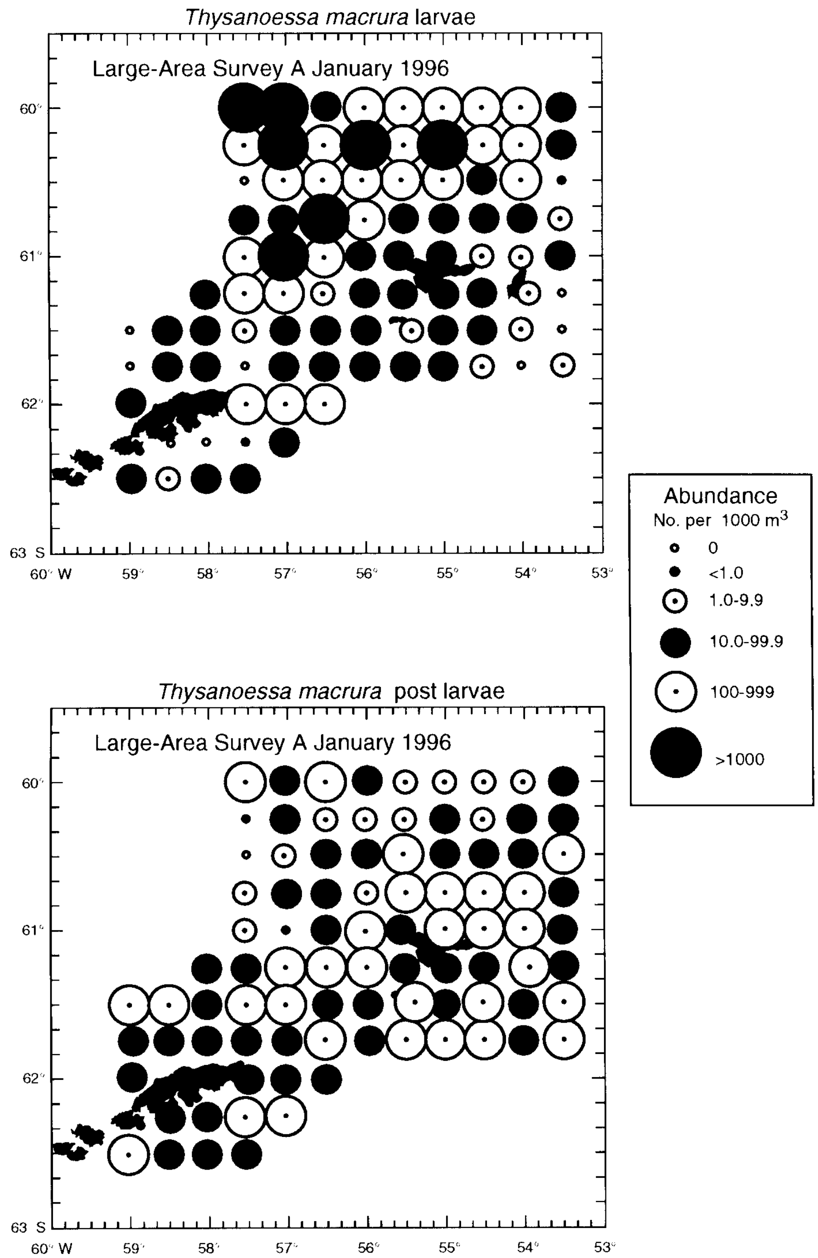


Figure 1. Distribution and abundance of larval and postlarval stages of *Thysanoessa macrura* in the Survey A area, January 1996.

Numerically dominant macrozooplankton taxa and total number of taxonomic categories collected during (A) January and (B) February and March large-area survey periods, 1994–1996.

NOTE: F is the frequency of occurrence (%) in tows. n.a. indicates taxon was not enumerated.

A	January 1996		January 1995		January 1994	
	F(%)	Mean	F(%)	Mean	F(%)	Mean
TAXON	(91 tows)	#/1000 m3	(90 tows)	#/1000 m3	(81 tows)	#/1000 m3
Copepods	100.0	794.4	98.9	652.7	30.0	41.3
Thysanoessa macrura (larvae)	90.1	308.5	36.7	15.9	n.a	n.a
Euphausia superba (postlarvae)	96.7	112.5	87.8	14.5	77.5	27.1
Thysanoessa macrura (postlarvae)	98.9	106.9	91.1	96.4	90.0	79.7
Limacina helicina	74.7	33.7	43.3	1.9	6.3	0.3
Salpa thompsoni	64.8	20.4	66.7	16.0	100.0	818.3
Chaetognaths	68.1	12.5	98.9	79.7	n.a	n.a
Ostracods	53.8	4.9	56.7	9.7	n.a	n.a
Themisto gaudichaudii	92.3	4.9	76.7	4.9	83.8	10.6
Euphausia superba (larvae)	22.0	2.7	22.2	135.8	n.a	n.a
Clione limacina	56.0	2.1	41.1	0.5	13.8	0.3
Euphausia frigida	30.8	1.9	50.0	9.8	17.5	3.8
Cyllopus magellanicus	41.8	1.6	24.4	0.2	82.5	6.3
Tomopteris carpenteri	60.4	0.9	84.4	4.2	37.5	2.5
Vibilia antarctica	48.4	0.5	22.2	0.2	98.8	11.8
Clio pyramidata	6.6	0.1	72.2	5.3	40.0	5.4
Total No. Taxa	70		76		46	

B	February-March 1996		February 1995		February-March 1994	
	F(%)	Mean	F(%)	Mean	F(%)	Mean
TAXON	(91 tows)	#/1000m3	(89 tows)	#/1000m3	(89 tows)	#/1000m3
Copepods	98.9	1387.0	100.0	3189.1	89.9	3090.2
Thysanoessa macrura (larvae)	87.9	414.4	79.8	276.9	n.a.	n.a.
Thysanoessa macrura (postlarvae)	91.2	143.3	93.3	161.3	91.0	118.9
Euphausia superba (postlarvae)	86.8	106.7	78.7	5.7	66.3	18.4
Chaetognaths	93.4	64.1	100.0	296.4	n.a.	n.a.
Salpa thompsoni	62.6	28.2	59.6	16.5	98.9	523.5
Euphausia superba (larvae)	62.6	13.9	93.3	3690.0	n.a.	n.a.
Ostracods	47.3	10.1	75.3	43.4	n.a.	n.a.
Euphausia frigida	54.9	9.0	60.7	16.7	61.8	25.9
Primno macropa	63.7	3.5	31.5	0.4	10.1	0.1
Themisto gaudichaudii	91.2	2.5	74.2	3.6	94.4	11.8
Cyllopus magellanicus	46.2	2.1	*25.8*	*0.7*	*79.8*	*4.4*
Spongiobranchaea australis	68.1	1.4	60.7	0.4	14.6	0.1
Vibilia antarctica	48.4	1.0	23.6	0.2	85.4	6.4
Electrona antarctica (larvae)	38.5	0.9	62.9	5.2	11.2	0.2
Hyperiella dilatata	52.7	0.8	24.7	0.1	36.0	0.6
Cyllopus lucasii	34.1	0.2	23.6	0.5	89.9	6.1
Total No. Taxa	67		65		33	

50 mm (figure 3). Virtually all (98 percent) were the aggregate form. Although chaetognaths were relatively frequent (68 percent of samples), they were not numerous (12.5 per 1,000 m^3) and ranked seventh in mean abundance. Early calyptopis stages of krill larvae were present in 22 percent of the samples, indicating successful spawning about 3–4 weeks earlier (Ross, Quetin, and Kirsch 1988). The pteropods *Limacina helicina* and *Clione limacina* were also relatively frequent and abundant.

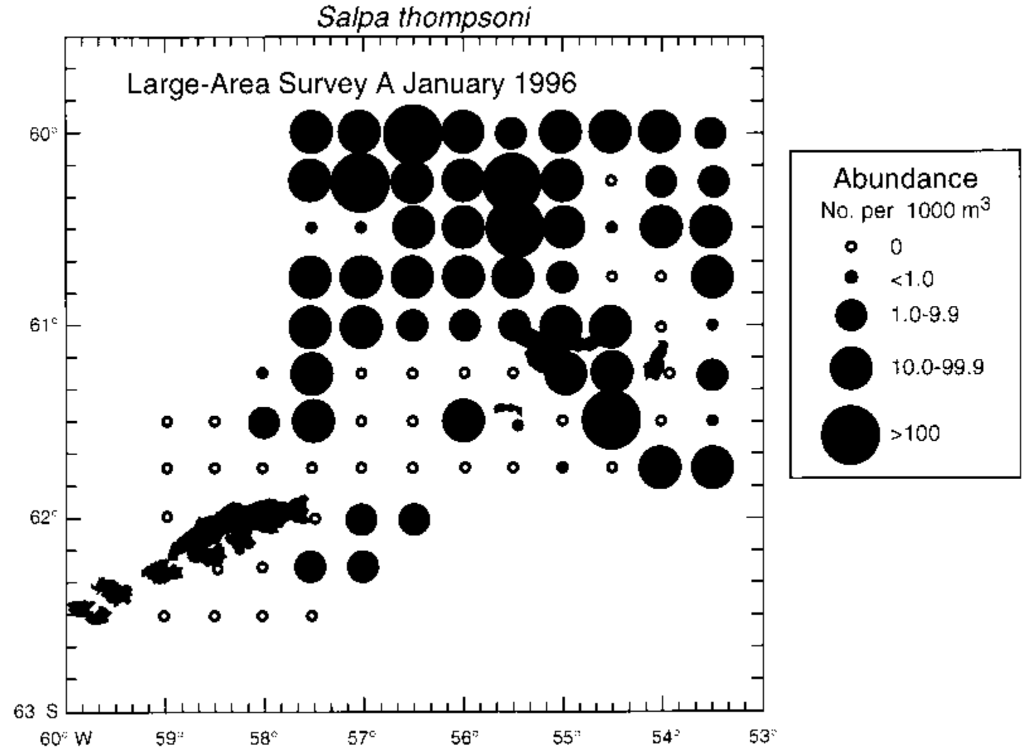


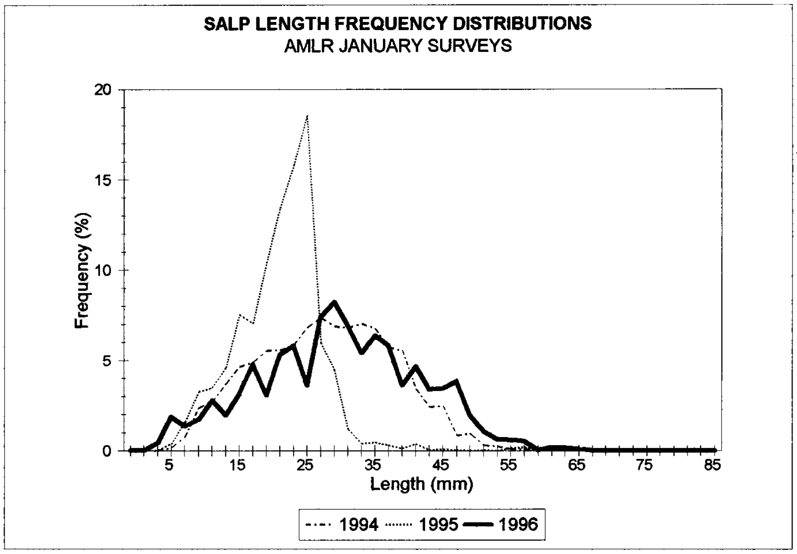
Figure 2. Distribution and abundance of *Salpa thompsoni* in the Survey A area, January 1996.

Sixty-seven zooplankton taxa were identified in Survey D samples (24 February to 8 March). Copepods again numerically dominated; they were present in 90 samples and their mean abundance value (1,387 per 1,000 m^3) was nearly twice that during January (table). The frequency of occurrence as well as mean and relative abundance values of postlarval and larval stages of *T. macrura* were similar to those observed during Survey A. Their distributions were also similar to those during January and negatively correlated (Spearman's R = –0.44; p<<0.001). Chaetognaths increased in frequency of occurrence (37 percent) and mean abundance (fivefold) over the previous month. Although krill larvae were encountered with greater frequency and abundance than during Survey A, they were not among the dominant taxa, ranking seventh in mean abundance. Calyptopis stages were most common (57 percent of stations, 85 percent of total larvae); early furcilia stages occurred at 18 percent of the stations. The pteropods *L. helicina* and *C. limacina* were notably less frequent and abundant than during Survey A.

Although mean salp abundance (28.2 per 1,000 m^3) was higher than during Survey A (table), the median catch of 0.9 per 1,000 m^3 was only 20 percent that in January indicating an overall abundance decrease across the area. Salps were again most frequent and abundant in the Drake Passage. Solitary forms made up a considerably larger proportion than during Survey A (21 percent). The overall size distribution was much more complex than during January (figure 3). Although a broad size range was again represented, small and large individuals were present in substantially greater proportions. A strong mode was centered around 7 to 12 mm lengths (25 percent of total); these were mostly aggregate forms (82 percent). Individuals larger than 54 mm made up 15 percent of the total; most of these (70 percent) were solitary forms. The 37 to 50 mm central size mode was due primarily to aggregate forms (88 percent). Cluster analysis indicated that the small-sized individuals were primarily distributed in northwestern portion of the survey area, whereas predominantly larger sizes were distributed to the south and east of these.

The overall median salp abundance decrease and composition changes between Surveys A and D were associated with the seasonal reproductive cycle and ontogenetic vertical migrations of *S. thompsoni* (Foxton 1966; Casareto and Nemoto 1986). Mean salp abundance values for the January through March survey periods in 1996 were similar to those of 1995; these values were two to three orders of magnitude lower than during the 1993 and 1994 "salp years" (table). Relatively low salp abundance in 1996 and 1995 followed winters with extensive sea-ice development; the 1993 and 1994 "salp years" followed winters with little or no sea-ice development, a condition apparently favoring explosive springtime salp population growth. The overall salp length frequency distribution during January 1996 was similar to that during January 1994, but differed significantly from that in 1995 (Kolmogorov-Smirnov test p<0.01; figure 3). Size composition differences probably result from differences in source areas (e.g., Bransfield Strait vs. Drake Passage) and length of the growing season.

The mean abundance values of postlarval *T. macrura* during 1996 were similar to those during 1994 and 1995 (table). Abundance of *T. macrura* larvae in January 1996 was an order of magnitude greater than in 1995, whereas that during February and March was 50 percent greater suggesting an earlier seasonal spawning period and increased larval production during 1996. The distinctly different larval and postlarval distribution patterns were previously reported for the February and March 1990 survey (Nordhausen 1991). Low



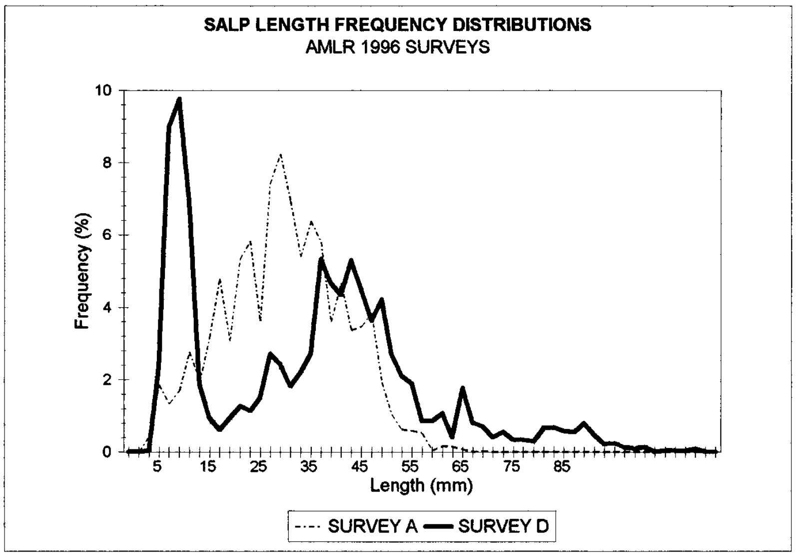


Figure 3. Length frequency distribution of salps in the Survey A area, January 1994, 1995, and 1996; and in the Survey A and Survey D areas in 1996.

numbers of krill larvae during February and March 1996 relative to 1995 suggest a later peak spawning period.

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AMLR program: The 7-year hitch—a meander in the circulation—near Elephant Island

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Using standard dynamic methods, we show the 7-year mean upper ocean circulation in the Elephant Island area relative to the 200- and 500-decibel (db) levels for two periods: January/February and February/March. Means were calculated using all conductivity-temperature-depth (CTD) stations within each 0.25° latitude × 0.5° longitude bin making up the Antarctic Marine Living Resources (AMLR) grid (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue).

In a larger geographical context, the AMLR grid straddles the southern Drake Passage, the Antarctic Continental Shelf, and the northern Bransfield Strait (figure 1 in Martin et al., *Antarctic Journal*, in this issue). Thus, one would expect to see the surface circulation include the southern arm of the eastward-setting Antarctic Circumpolar Current (ACC), called the Continental Water Boundary (Nowlin and Clifford 1982), the western boundary of the Weddell–Scotia Confluence (Nast et al. 1988), the counter-flowing East Wind Drift, the Bransfield Current, and perhaps some manifestation of water flowing out of the Weddell Sea and entering the Bransfield Strait (Gordon and Nowlin 1978).

Over the 7 years, we have been impressed with the consistency of the upper-level water structure and geostrophic flow calculated from CTD casts. We have noted month-to-month and year-to-year differences in the thermohaline structure (Amos 1993), but the geostrophy remains similar, both interannually and between the mid- and late-summer seasons of the two AMLR legs.

The general flow is from southwest to northeast and is similar at both the 200-db and the 500-db level (figure 1*A*, *B*), indicating that the motion of the upper few hundred meters is nearly uniform. Three main flow paths are apparent:

- north of the South Shetlands in the Drake Passage paralleling the continental shelf-break,
- south of King George Island in the Bransfield Strait, and
- east of Elephant Island near Clarence Island.

It should also be noted that the AMLR grid pattern is not designed for complete coverage of some of the areas of interest to the oceanographer; rather, the coverage must be a compromise to accommodate all of the areas of krill research (acoustics, zooplankton, phytoplankton, krill distribution, penguin and fur seal tracking, etc.) in the available cruise time.

Major reverse flow and East Wind Drift are not evident, but two or possibly three meanderlike features are discernible:

- one in the northwest grid section in the Drake Passage,
- one east of Clarence Island, and
- the possible third, a smaller eddylike feature, might occur between Clarence and Elephant Islands.

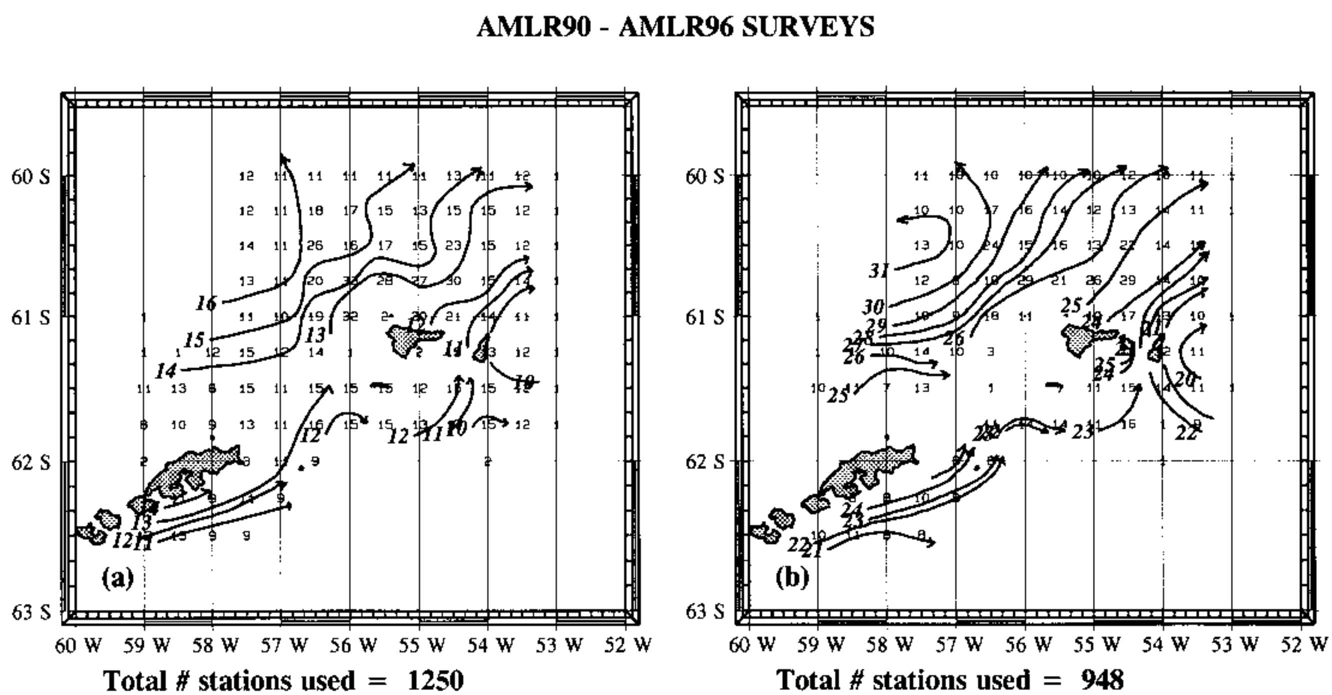

Figure 1. Mean dynamic topography of AMLR study area. Streamlines plotted with respect to (*A*) 200 db and (*B*) 500 db at the surface (dynamic centimeters). Numbers at grid locations are number of stations averaged in each grid over a 7-year period.

Quasi-permanent* features such as these might affect krill distribution. We do not know if the Drake Passage feature is a meander in the flow or an eddy, but during some years' surveys, the streamlines are closed, indicating an eddy. The concentration of streamlines running southwest to northeast marks the boundary front that separates Drake Passage waters from those of the continental shelf and the Bransfield Strait. The northwest corner of the Drake water where the meander occurs is generally a region of low surface and integrated chlorophyll-*a* concentrations (Villafañe, Helbling, and Holm-Hansen 1994) and low inorganic nutrients (Silva et al. 1994) but variable krill abundance from acoustic profiles (e.g., Hewitt and Demer 1994) and variable krill and salp abundance in net tows (Loeb and Siegel 1994).

Does the mean flow pattern and location of meanders vary substantially seasonally? We compare the slope of the sea surface relative to 500 db for all stations made during January/February (figure 2*A*) and February/March (figure 2*B*). The time periods display no essential differences. Both meanderlike features are present, as well as the smaller eddy feature between Clarence and Elephant Islands. Also shown in figure 2*A* are the tracks of three barometer drifters deployed during January 1995. Their tracks follow the mean streamlines closely with the circular motion of the northernmost drifter in the general vicinity of the meander in the northwest corner, although it describes both clockwise and anticlockwise rotations.

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*Quasi-permanent, because we know only that they exist during the summer AMLR study period.

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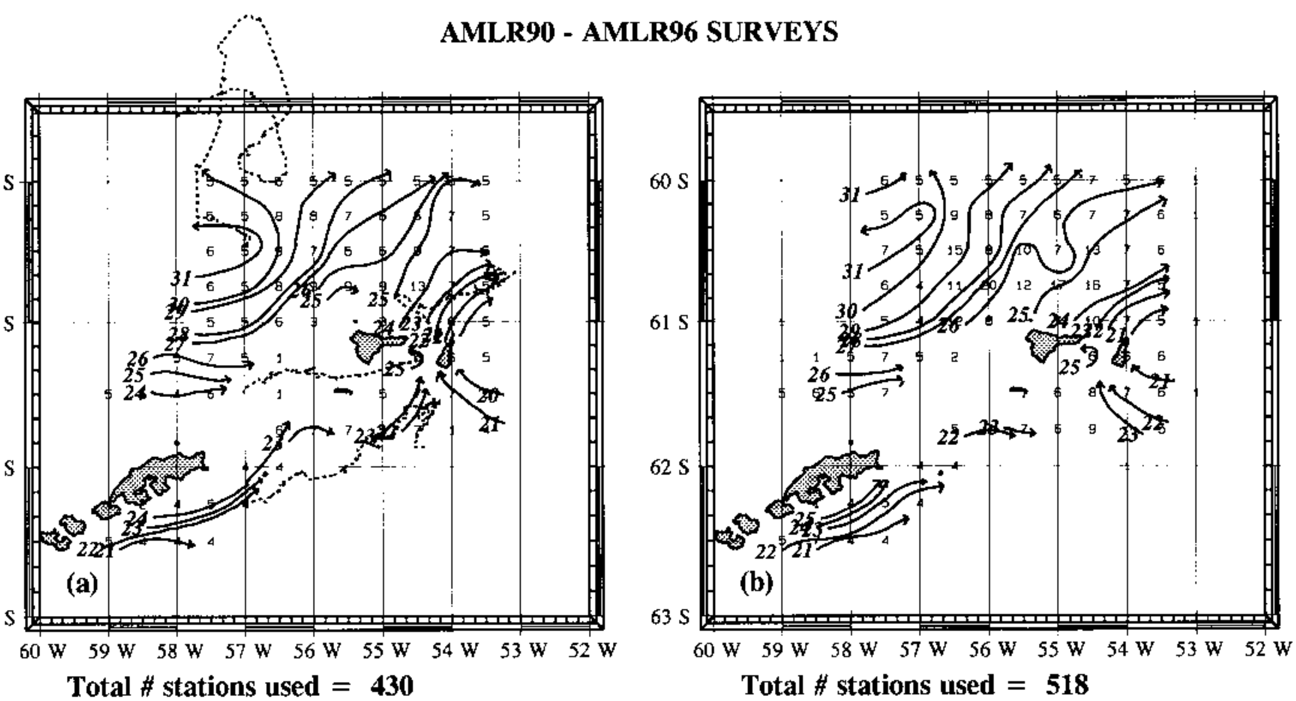

Figure 2. Mean dynamic topography of AMLR study area. Streamlines plotted for (*A*) January/February and (*B*) February/March, with respect to 500 db at the surface (dynamic centimeters). Numbers at grid locations are number of stations averaged in each grid. Dotted lines in (*A*) are tracks of drifters launched in January 1995.

AMLR program: Fur seal and penguin studies at Seal Island, South Shetland Islands, Antarctica, 1995–1996 austral summer

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Pinniped and seabird research was conducted by the Southwest Fisheries Science Center at Seal Island, South Shetland Islands, Antarctica, during the 1995–1996 austral summer (*see* Martin, Hewitt, and Holt, *Antarctic Journal*, in this issue). The National Oceanic and Atmospheric Administration (NOAA) maintains a field camp at this location which is occupied annually. This long-term research project focuses on the relationship of top predators (fur seals and seabirds), their prey (krill and fish), and their surrounding environment. These studies are conducted in support of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Program (CEMP). Due to the impending closure of the Seal Island camp site and efforts to select a new site, objectives of the 1995–1996 field season were abbreviated from previous years and were as follows:

- to monitor antarctic fur seal (*Arctocephalus gazella*) pup growth, pup production, abundance, survival, and recruitment; and
- to assess long-term trends in chinstrap penguin (*Pygoscelis antarctica*) and macaroni penguin (*Eudyptes chrysolophus*) abundance, fledgling size, survival, breeding success, and recruitment according to CEMP and other standard protocols.

Weights of 101 antarctic fur seal pups (51 female, 50 male) were measured on 27 January 1996. Male pups weighed on average 13.51 kilograms (standard deviation, 2.00), and female pups weighed on average 11.58 kilograms (standard deviation, 1.57). These average weights for this period in the season were the heaviest recorded since 1991–1992 for both male and female pups. Because of the abbreviated field season, the exact pupping chronology is not known. The heavier than normal weights could be attributed to a shift in breeding chronology, or increased availability of prey. The 1995–1996 Antarctic Marine Living Resources (AMLR) Field Season Report notes higher than normal krill abundance estimates (Martin 1996).

At least 281 pups were born on Seal Island during the 1995–1996 austral summer. Pup counts commenced approximately one month after the typical peak in seal pupping occurs, so it is reasonable to assume this number was larger earlier in the season. It is very close, however, to the previous two seasons' birth totals of 286 (1994–1995) and 299 (1993–1994). A census of nearby rookeries (Large Leap and Cave Colony) on 5 February 1996 yielded 288 and 101 pups, respectively. Total births for the Seal Island archipelago were at least 670 for the 1995–1996 season, compared to 699 for the 1994–1995 season, and 666 for the 1993–1994 season.

Seventy-four known-aged fur seals (34 males, 40 females) tagged as pups from the 1986–1987 to 1993–1994 austral summers were sighted in 1995–1996. Of the 40 females, 16 were sighted with a pup. Long-term resight data should provide estimates of age at first reproduction, and cohort and age specific mortality.

Ten chinstrap penguin colonies were censused on 28 January 1996 at approximately 2/3 creche. In total, 1,097 chicks were counted, the lowest count for these colonies in the 7 years of the census, which averaged 1,511 chicks. One of the 10 colonies did not exist for the first time since the census began. Timing of the start of chinstrap chick fledging, 16 February 1996, and mean fledgling weight, 3.12 kilograms (standard deviation, 0.32), were consistent with previous seasons. This agreement would suggest the decline in the breeding population was not due to a decrease in prey available during the breeding season.

Census of all macaroni penguin colonies on 26 January 1996 at approximate completion of creche yielded 194 chicks. This number is slightly lower than average (203) for the last 7 years of census.

From the 1987–1988 austral summer to the 1993–1994 austral summer, approximately 2,000 chinstrap chicks and 70 macaroni chicks were banded each year. In 1995–1996, 444 known-aged chinstrap penguins and 34 known-aged macaroni penguins were sighted. Chinstrap penguins 2–4 years old constituted 86 percent of the resights, whereas 5–8 year olds made up only 14 percent. These resights can provide data on age and cohort specific mortality, age at first reproduction, and breeding success of age classes.

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